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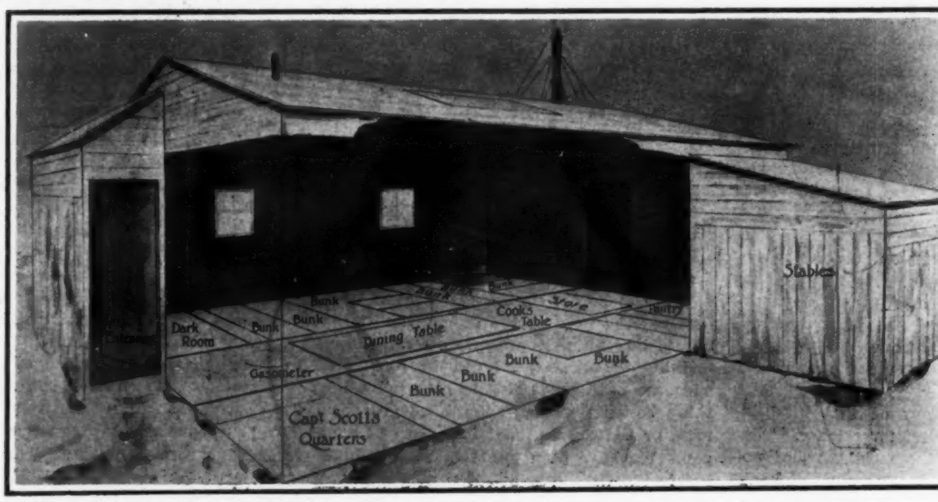
THE BRITISH ANTARCTIC EXPEDITION.

CAPT. SCOTT'S EXPEDITION TO THE SOUTH POLE.

THE interesting announcement was made that the British Antarctic Expedition has started for the south a month or six weeks earlier than was previously expected. Much progress has been made with various sections of the expedition. The accompanying illustrations and descriptive matter of the ship and of the hut in which the members of the expedition will live while on shore are taken from the Sphere. The 1910 expedition will not winter on the ship as in 1902-4 but will establish a base on shore, and the "Terra Nova" will therefore be able to act as relief ship, as was the case in Sir Ernest Shackleton's Expedition.

A recent number of The Geographical Journal opened with an interesting account of Capt. Scott's plans for his proposed Antarctic Expedition, coupled with an indication of the official geographical attitude toward the enterprise. So far as the attainment of the South Pole is concerned it is pointed out that only about a hundred miles separate Mr. Shackleton's farthest south from that point. There is no reason to suppose that that particular spot exhibits any features of exceptional scientific interest, and the Royal Geographical Society could hardly advocate an expedition with the South Pole as its sole objective. On the other hand, it is useless to deny that there is a widespread feeling that this feat should be accomplished by an expedition sailing from this country. "As citizens," says The Geographical Journal, "we all share in this sentiment, and we may, moreover, as geographers legitimately take full use of this opportunity of obtaining public assistance for Antarctic exploration." As regards Capt. Scott's proposal to establish two bases, one in McMurdo Sound at the western end of Ross's great ice barrier, the other on King Edward VII. Land at the eastern end of the barrier, the Geographical Journal suggests that it is quite likely that the attempt to reach the South Pole will again be made by the route opened up by Capt. Scott and Mr. Shackleton from the western end of the barrier. It is stated that it will entirely depend on circumstances which of the two bases is used as the headquarters



THE HUT IN WHICH THE 1910 EXPEDITION WILL LIVE AFTER THE SHIP HAS LANDED THEM ON THE ANTARCTIC CONTINENT.

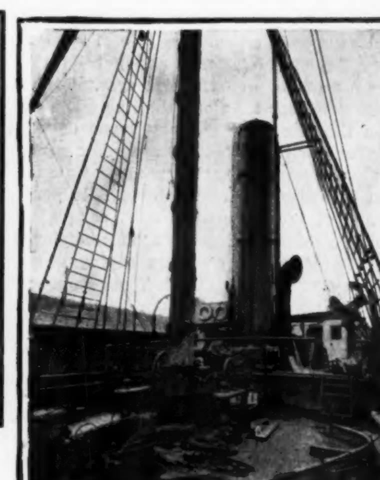
This hut is now being erected in the dock district not far from the wharf where the "Terra Nova" lies. Her internal arrangements are only approximately determined upon, as the final divisions of the hut will be settled when this compact little dwelling place is erected on the Antarctic snows

THE STERN OF THE "TERRA NOVA."

Her gilded stern bears the words "Terra Nova," St. John's, N. S.

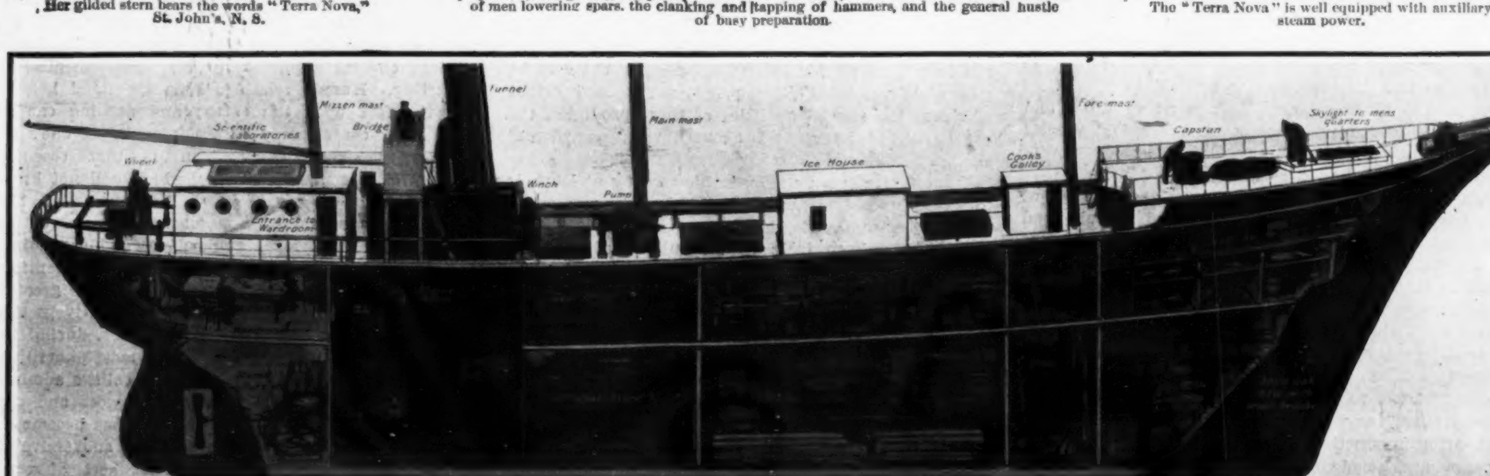
SOME SEASONED ANTARCTIC SEAMEN WHO WILL AGAIN ADVENTURE THE ICY SOUTH.

Many of the men who were with Capt. Scott in 1892-4 are again accompanying him to the far south—a few lucky ones it is hoped to the farthest south. Some of these men are now actually employed in getting things ship-shape on the "Terra Nova," which resounds with the shouts of men lowering spars, the clanking and flapping of hammers, and the general hustle of busy preparation.



AFTER QUARTERS OF THE "TERRA NOVA."

The "Terra Nova" is well equipped with auxiliary steam power.



SECTIONAL VIEW OF THE 1910 ANTARCTIC EXPEDITION SHIP, THE "TERRA NOVA," SHOWING THE DISPOSITION OF STORES, ENGINE ROOM, LABORATORIES, AND OFFICER'S AND MEN'S QUARTERS.

THE BRITISH ANTARCTIC EXPEDITION.

of the main force of the expedition. Should a favorable spot be found in King Edward VII. Land the greater force may be landed there, and the lesser force be intrusted with the work of carrying out the important station observations to be made in McMurdo Sound and the collection of further details about the geographical and geological features of the region.

The "Terra Nova" is the largest and the strongest of the old Scottish whalers. Built at Dundee in 1884, she is 187 feet in length and 31½ feet in beam; that is, 15 feet longer but 2½ feet narrower than the "Discovery." She is considered the best ship ever launched for the Greenland whale trade and has always been a most profitable possession to her owners. Of late years, consequent on some decline in the whaling business, she has been occupied in seal-hunting in the northern waters, sailing from St. John's, N. F.

The "Terra Nova," however, has not confined herself to the humdrum of trading. In 1903 she was purchased by the Admiralty as relief ship for the "Discovery" Expedition, and after being considerably strengthened duly made her appearance in the Ross Sea as "The Voyage of the 'Discovery'" relates. The year 1905 saw her in the service of the North Polar Expedition, on a visit to Franz Josef Land. Thus she has ranged from the great ice barrier in the south to the north polar pack—from extreme to extreme of the navigable waters of the globe. The size and strength of the ship make her a fitting receptacle for the extensive equipment which it is necessary she should carry for the full success of the plans of the expedition. It is certainly most gratifying to think that the expedition will sail in a ship which is both British-built and British-owned.

The "Terra Nova" is a great deal larger than the "Nimrod." The increased size is necessary for the more extensive plant of the expedition, for it is held that Sir Ernest Shackleton's "farthest south" can only be surpassed by taking more men and more equipment. Further, it is to be remembered that the programme of the expedition includes two bases for the purpose of scientific work and geographical exploration, and of course this also necessitates a large vessel. The "Terra Nova" is of the ordinary whaler type. She is a sailing ship with auxiliary steam-power. Most of these ships are comparatively poor sailers, but in making long passages with a fair wind the sails are, of course, an enormous advantage, and in going to the south they are a great aid in saving coal. The roominess of the "Terra Nova" will be much appreciated by both officers and men of the expedition.

SCIENCE AND THE HUMANITIES.*

THE VALUE OF GENERAL CULTURE TO SCIENTIFIC INQUIRY.

BY PROF. ALBERT G. KELLER.

Not so many years ago, in his famous book on education, Herbert Spencer put forth a powerful plea for the study of science. At that time, in England at least, science stood in need of so adroit and compelling an advocate; for classicism was dominant in the educational field, and had taken on the arrogant assurance of the unchallenged. But Spencer's gauntlet fell with no uncertain sound; he made about all there was to make out of a strong position. The vigor of his assault is still borne witness to in certain quarters, by a scarcely waning exasperation with the essay on education and the author of it.

Nowadays, however, an advocacy of that kind is not called for—as respects its brief for science. The book on education is now, for the most part, of no more than historic value. For the very watchword of our age is science. It is the fashion to profess scientific method, whatever one may be doing. Historians caper about in their enthusiasm over scientific method in history, and even wish to call history a science. Even the philosophers profess to analyze scientific method and the use of the scientific imagination as new phenomena capable of being resolved into their psychical elements and put together again before astonished and troubled eyes. Truly science has been victorious all along the line.

In the face of this happy vogue of what was once despised and rejected by a former generation, I do not propose to say that it is about time for the pendulum to swing the other way. This pendulum figure is one of those oracular, trite, complacent and inexpressibly exasperating metaphors employed by people who imagine that they are saying something, when they are actually dinning into our ears, with damnable iteration: "Two and two are four! Two and two are four!" But I do wish to remind fellow scientists of the inevitableness of the humanities and of humanity; to assert not only that our lives may be enriched by the pursuit of culture in diverse forms; not only to express my belief that our destinies must be impoverished by the renunciation of all lines save one; but also to insist upon the more concrete contention that our special scientific work is bound to suffer as a consequence of the neglect of that for which the "humanities" stand.

Since the man's work must always be a function of the man, it is essential for the best work that the man shall refine his mind in all ways possible to him before he has the assurance to attempt to give of its products to other people. Refinement of mind and refinement of character, moreover, are not so readily disassociated as we have sometimes been given to understand. There is something in the nature of truth that does not brook the investigating hand of the common churl. The narrow minded, meanly read scientist is competent, perhaps, for the coarser tasks of the truth searcher; but his mind and heart are not open to those impalpable influences which play so significant a part in enabling the scientist to correlate his work with human life, to throw it into line with cosmic forces, rather than to leave it in isolation as a poor side issue, soon antedated and passed by. It is never possible to predict from just what source that "inspiration," as we call it, will come—that suddenly appearing perspective which clarifies the vistas of the obscure and humdrum, and affords a new orientation. And yet it is the grandest ideal of the scientist to receive at some rare time some pregnant hint which shall transform the laboriously gathered baser metals of his dogged, uninspired research into the gold of a comprehensive synthesis. Let him therefore perfect his receptivity for his work's sake, if for no other; let him become and remain sensitive in the most delicate sense—alive to the subtler suggestions which ring in the ear of the cultural monotone, but whose quality is outside the limited range of his perception.

But—to leave the less tangible, and what may seem to some to be the sentimental aspects of the case before us—the need of the humanities is a very actual one to any scientist who essays self-expression. The training of no scientist can be considered as truly adequate until he is able to convey his idea in something better than the amorphous grunts of the cave man, or the conventional formulæ of his peculiar jargon. We have been prone to beat with the forehead before the Germans; but it is evidence of the passing of irrational fetichism that at last timorous and other murmurs are to be caught floating down the breeze to the effect that, after all, some fault can be found with the Teutonic style. One great and downright scholar has warned some of us that we must always translate a portentous, mysterious-sounding German sentence into English—before one lies down in the track of its oozy involutions and lets it back in over him—in order to see whether it really means anything after all. "The German language," this man used to say, "lends itself easily to pathos."

American scientific publication is open, I believe, to much less of this sort of criticism; nevertheless one says but little for it, when he admits this. It is a long way from the normal American scientific production up to that of a Huxley—for Huxley's essays are real literature, but are seldom hallmarked as such by being served up in courses on English literature. Our scientific writing is full of mannerisms; it is often entirely barren of choice in expression, of lightness of touch, and of grace in general. It is feebly imitative of uninspired models. Sometime in the glacial age the primitive scientist coined all the little stock of pet scientific expressions while the primitive politician was first "pointing with pride," or "viewing with alarm"; and both scientists and politicians hand on the now somewhat debased currency with cheerful pedantry and naive trust. One gets as weary of this stereotyped and slavish or slothful unoriginality as he does of the incessant rustic jibe or colloquialism. A certain administrator is reported to have struck the swan-mark on all his geese by reporting them to be men of "fierce mind"; but people got to saying that whatever the mental qualities of these prodigies, the experience of being told about them was "fierce" enough for anybody.

What the scientist needs, in his writing at least, is to have some style about him—if he is going to do himself justice, that is, and appear to those of his colleagues who have taste as an anticipated pleasure rather than as a necessary bore. And certainly, if a scientist is to attempt in any degree to popularize science, he must get some sort of personality and finish into his presentations. No man, not even a Lincoln, picked his style out of thin air; one gets that sort of thing, if we are to believe biographies and autobiographies, out of the much association with the great masters of the humanities.

I have mentioned the popularization of science. To some scientists, I am aware, this function seems to be an unworthy one. So it may be—and dangerous, too, to the popularizer's career—if it means writing or lecturing to suit the taste of many a popular magazine or sensation-seeking audience; but it is not unworthy when the essay or the lecture is of the Tyndall stamp. Long centuries ago, a conceited but really gifted Roman declared that it was a thing to be ashamed of, if one had so submerged himself in study as to be unable to bear forth any fruit of his labors to the common store. It is indeed part of the humanities to be willing to share with the knowledge-seeking public what portion of one's intellectual acquisition they can apprehend. The public is no longer content with the old style clerical harangue—science, in its popularization, has helped secure that much of advance, at the least. Referring to this obsolescent style of popular discourse, Galton has said: "The religious instructor in every creed is one who makes it his profession to saturate his pupils with prejudice." Those days are over; science is now the mode; and it is the business of the scientist to saturate the largest possible portion of the public with a leaning in favor of what he regards as true thinking. These are no days, and this is no country, for scientific ascetics, practising through lone vigils the art of superciliousness as respects the uninformed or the non-elect. "Pure" science may be pure, to adopt Carlyle's expression, "as dead dry sand is pure."

To all, or nearly all, there soon must come a test of your "humanity," if not of your "humanities"—of your interest in man, if not of your acquaintance with the most noteworthy flights of men's minds. The professional engineer must meet his assistants and his force of laborers—the teacher of science must have some sort of relations with his institution, his colleagues, and his students. I am scarcely competent to speak of the relation between the directors of labor and those directed, but certainly the throes in which sections of our country groan from time to time, indicate the need of men of large sympathies and of tact, as well as of trained judgment in places of power throughout the industrial system. Speaking, however, of the teacher, and in particular of his relations to those duties which are imposed upon him by the logic of the tuition fee and of the endowment of instruction, it has always seemed to me that it is the essentially narrow minded man who despises, or affects to despise, these obligations. Especially does it seem, if he is young, that his sense of the values of things must be perverted or atrophied—that he is a morbid character too little in sympathy with the world of men—if he can allow himself to be drawn off into endless acquiring, to the virtual neglect of imparting. Human relations keep the mind healthy and the feet upon the earth; and nothing can be more truly contributory to the integrity of one's adherence to truth-seeking than is that essential honesty of mind and character which will not brook the thought of evasion of duty. Both the college and the scientific school have numbered great scientists among their most loyal and self-sacrificing administrators, and their most patient and conscientious teachers. Willard Gibbs, to name one of the greatest of Yale scientists, met, it is true, relatively few students, and perhaps no undergraduates, during the last years of his life; but he was the most punctilious of men in assuming his share in the college administration—in that dealing with student woes and that guiding of student destinies, which it has become, in some measure, the fashion to decry as subversive of, or deadening to scholarship. That sort of work never operated to deaden the mind of a Whitney, a Penfield or a Sumner. There is scarcely any activity connected with research which is so wholesome in its results along the line of self-correction, as is the process of imparting to the less advanced.

* The Yale Scientific Monthly.

Even the case of Darwin supports this contention. Owing to his chronic invalidism, Darwin became in many respects a virtual recluse. But he maintained a scientific correspondence with all sorts and conditions of men—not seldom replying at length to fervent communications from youths half again more zealous than baked—a literary relationship of which Weismann writes: "The number of people with whom he carried on a scientific correspondence is simply astounding." "He received many letters," says his son, "from foolish, unscrupulous people, and all of these received replies." Darwin entered largely into the simple life of the village where he lived, serving as treasurer of a Friendly Club for thirty years, and even acting as county magistrate. One can easily infer that he could not have viewed his relations to a college, or even backward students, with indifference.

The reason why the mind devoted to science needs these "humanities" is because one-sided development means deformity. Darwin is sometimes cited as a case in point. In a famous passage of his autobiography he deplores the fact that poetry, art and music have ceased to gain the response from his mind and heart that they had once evoked.

"My mind," he says, "seems to have become a kind of machine for grinding general laws out of large collections of facts, but why this should have caused the atrophy of that part of the brain alone on which the higher tastes depend, I cannot conceive. A man with a mind more highly organized or better constituted than mine would not, I suppose, have thus suffered; and if I had to live my life again, I would have made a rule to read some poetry and listen to some music at least once every week; for perhaps the parts of my brain now atrophied would thus have been kept active through use. The loss of these tastes is a loss of happiness, and may possibly be injurious to the intellect, and more probably to the moral character, by enfeebling the emotional part of our nature."

Thus, at the end of his life, the greatest scientific figure of modern times, albeit with characteristic self-depreciation, laid down the principle that the greatest scientist must take account of the emotional factor—must be an all-around man. Darwin at least saw the worth of what he thought he had himself sacrificed; and here, it may be recalled, Spencer fell short of Darwin, precisely along those lines where Darwin thought he himself had fallen short of self-realization. The relationship between science and the humanities is not one of opposition, but a complementary relationship, rather, of mutual reinforcement. One of the things most sure to awaken distrust of the scholar or author is the conviction, often an intuitive one, that he does not see life whole. This is why the specialist has so often cut but a sorry figure in the estimation of his fellow men—why the scientist has been regarded as a cold-blooded freak, and the humanist as a gushing, impractical dilettante. The humanities have often needed an injection of that brand of science which Huxley describes as "organized common sense"; and science has needed "humanization," and will always need it, so long as the human mind is not intellect alone

This admixture of the humanities must come early. Most of us who are not specialists in the humanities have done the bulk of our readings in literature and have made our ventures into art and music during college days, or shortly thereafter. Once involved in the sweep of competition, or in the routine of a specialty, time and energy have not been left over for extensive forays outside the chosen field. This is one of the reasons why one should deplore premature specialization. I firmly believe that no one should allow himself to get past his doctor's degree, or what may correspond to that stage, without immersing himself for a time in a discipline which, if he is to be a scientist, is calculated to appeal to those of his faculties which seem unlikely to enter largely and directly into his career. They will so enter, for, as I have tried to intimate, the most wholesome mental product is secured by a species of cross-fertilization between the mental faculties. The love of a scientist for the humanities—of all kinds—may, at the humblest, attain for him a relaxation and relieve the tension that is always approaching the breaking point; or it may determine, in large measure, the mood in which he approaches his labors; or it may contribute to secure that perspective which results in a non-distorted apprehension of values; and, if it can do nothing else, it is sure to aid one in imparting what he finds out. The symmetry of the work is a function of the symmetry of the mind behind it.

It is at this season of the year that one restlessly looks forward to the completion of another lap in the race for an education and wonders what will be the most satisfactory way of spending the few months of swiftly approaching vacation. Some few indeed are so fortunate as to have most alluring opportunities of trips abroad or some other definite plans which assure them of both a happy and profitably spent vacation. On the other hand are arrayed that large bulk of the undergraduates whose plans are still uncrystallized and whose desires even have as yet found nothing definite to focus upon. To this large majority we address ourselves.

Most Yale men know in a hazy way that there is a place called Northfield where the Y. M. C. A. contingent of the college is apt to assemble after the close of the spring term. Few believe that it is a fit place for the live and energetic who have not the weight of wicked man upon their shoulders. To the initiated, however, Northfield means far more than a place of solemnity for the extremely religious. Those who have been fortunate enough to enjoy the pleasures of comradeship and healthy contact with men of their own kind, those who have lived for a week or ten days in that indescribable atmosphere of clean thought and vigorous outdoor life found at Northfield know that at no other place can the short beginning period of their vacation be spent more profitably or more enjoyably.

It is a great gathering of college men in which are found representatives from nearly every large school and college in eastern United States and Canada. Yale is usually the best represented institution at the conference. Yearly one hundred and thirty or forty Yale men attend. Regretably Sheff. men in general have not in previous years availed themselves of the opportunity of going to Northfield.

The life at the conference is varied. Prominent speakers may be heard daily and the ideas expressed by them bear the attention of all serious minded men. Combined with this spiritual side of the life is the great diversity of outdoor amusement. There are good tennis courts. The swimming is excellent. Baseball games are played every afternoon. A track meet and a grand celebration and bonfire are events which make the life anything but monotonous.

To those men who have not yet planned anything for the period between June 24th and July 3rd we can recommend no more desirable a place to visit than Northfield. It is a distinctively American institution worthy of your recognition.

EUGENICS AND MENDELISM.

IMPROVING THE HUMAN RACE.

ANYONE who thinks about the matter at all knows full well, says the Medical Record, that in European overcrowded countries and in cities in all parts of the world the condition of the masses is susceptible of great improvement from every point of view. This statement, indeed, puts the case mildly, for in the largest cities the state in which the very poor live is a direct and constant menace to the nation and to the white race generally. Too many individuals are born nowadays who are handicapped from the outset by physical and mental disabilities, due to poverty, heredity, that is, if heredity plays an important part in the physical and mental make up, to environment, and to an upbringing which render them unfit to wage successfully the battle of life. Such persons are a detriment to the nation to which they belong, and the most disquieting feature of the situation is that they increase at a far more rapid rate than the better class of citizens. This brings about the tendency not merely to further degeneration, in itself sufficiently alarming, but what is even more alarming, a deterioration of the general average. Thus certain countries of Europe are faced with these disturbing facts, that not only is the population of their towns degenerating, but the race, as a whole, is deteriorating in body and mind. The nations whose inhabitants are chiefly in towns are in the worst position, but even in America affairs in this respect do not give cause for unmixed satisfaction. In a few words, it may be stated as an undoubted fact that in all parts of the civilized world the least desirable part of the population from a physical and mental standpoint is producing more numerous progeny, and it would seem that unless means can be devised to stay this flood of the unfit, in the course of time the entire race must descend to a lower level as regards physical and mental qualities. Men of light and learning everywhere recognize the gravity of the position, and various measures have been suggested, some of which have been in part adopted, to keep the race at a high standard.

Of late the aid of eugenics and more recently still that of Mendelism has been invoked in this direction, and by some enthusiasts it is declared that in the practice of these theories the solution of the problem lies. In this country, during recent years, a great deal has been heard of stirpiculture and the physical examination of those wishing to be married has been strongly urged. So far as the doctrines of Mendel and his disciples are concerned, less interest appears to have been taken in these in America. However, in Europe and perhaps, particularly, in Great Britain, the followers of Mendel have been strenuously insistent that in the adoption of these teachings rests the salvation, or rather, the physical and mental regeneration of the race. A few far-seeing persons have attempted to stem this tide of enthusiasm and to indicate the exact state of the case. Among these is Dr. Square Sprigge, the editor of the Lancet, who in the Contemporary Review for November, 1909, subjects the matter to close scrutiny and throws the clear searchlight of common sense upon the points at issue. In the first instance, he very appositely draws attention to the fact that the problems of heredity are not yet solved, so as to be able to lay down any hard and fast dicta to inherited predisposition to disease. At a debate on heredity from the standpoint of disease held by the British Royal Society of Medicine in 1908, it was shown that certain obscure and rare nervous diseases were hereditary and that organic epilepsy might be inherited. With regard to cancer some of the most prominent authorities deny that this disease can be proved to be hereditary, while several of the recent workers on tuberculosis believe that the condition is in no wise inherited, and a well-known British authority confessed himself as skeptical of even a predisposition to tuberculosis being inherited. Of course, the obvious degenerates, drunkards, imbeciles, and those profoundly tainted with blood poisoning, should be debarred, if possible, from propagating their kind, but outside this class, who, in the present position of knowledge regarding the laws of heredity, is to say which couple is fit to mate and which is unfit?

The followers of Mendel assert that in the teachings of the remarkable Abbot of Brünn is to be found the solution of the fundamental riddles of heredity, and if this be so there is reason to believe that the question of suitable marriages may be successfully attacked by them. It must be borne in mind though that neither the truths laid bare by Mendel himself nor the advance on these truths made by his disciples has up to the present solved the problem. Mendel discovered marvelous facts by his experiments in flower culture, notably in pea fertilization, and his followers have greatly improved on his experiments in fowl and rabbit breeding. But the result of experiments thus far do not authorize the statement that human breeding can be influenced in a similar way, although they may point to a possibility in that direction. Indeed, even in flower culture it is not known, except by individual experiment, what qualities will respond to the Mendelian notation, and whether such will be dominant or recessive in action. The possibility of avoiding the transmission in certain plants of certain qualities has been demonstrated by avoiding certain alliances, and if any practical rules as to the transmission of disease can be given to medical men by the Mendelists, a great step in advance will have been made in regard to the position of Mendelism in eugenics. Now, according to Sir William Gowers, with respect to disease, the Mendelian theory appears to be borne out in the transmission only of pseudohypertrophic paralysis. The Mendelian theory has infinite possibilities in regard to the betterment physically and mentally of the human race, but as yet these are but possibilities. On the whole, Sprigge is far from being convinced of the value of the medical certificate before marriage, as one of the chief planks of the eugenic platform, until the Mendelians have supplied the medical profession with more accurate knowledge of the workings of heredity upon which to base their decisions.

It is the desire and object of medical and scientific men to improve the breed of human beings, but, on the other hand, it is not the intention of these men to lead the ignorant astray as to the chances of so doing. A little learning is a dangerous thing, and it is those who know little who are generally most certain concerning partially known scientific truths. This is the case with respect to eugenics and Mendelism. The learned biologist may hope and imagine that the most sanguine expectations of the Mendelists may be realized, but the dabbler in science is positive they will be and talks as if they were already realized.

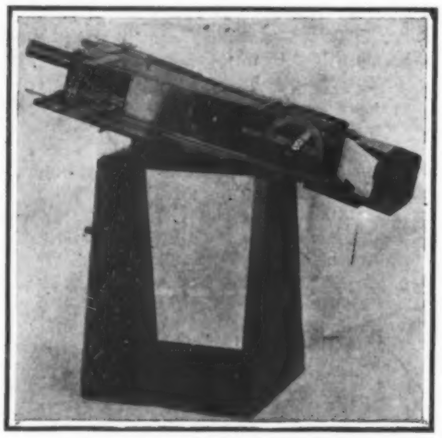
THE QUALITY OF LIGHT.*

ARTIFICIAL LIGHT VERSUS DAYLIGHT.

BY PAUL F. BAUDER.

WHAT is the relative value of the light given by artificial illuminants as an artificial duplicate of daylight? Such a broad use of the term daylight has led to much discussion between the advocates of each artificial light source. It is the purpose of the author to submit results of some investigations upon which an estimate can be formed as to the comparative merits of each of the more common commercial illuminants.

At best, daylight is a great variable, but neverthe-



IVES COLORIMETER.

less it has generally been the light to which artificial sources have been referred. It is apparent that this light must have certain fundamental characteristics which make it a standard. A standard of illumination must, however, have certain requirements, the most important of which is constancy. There are so many varying conditions which affect the light from the sun that no definite standardization of average daylight has been universally agreed upon by investigators. Those qualities, for a standard unit of illumination, which mark the sun as the ideal illuminant for the majority of conditions may be classified under the following headings:

Intensity.
Color value.
Direction of rays.
Ability to reveal detail.
Adaptability.

These five qualities will be discussed separately.

* Paper read before the Franklin Institute.

INTENSITY OF DAYLIGHT ILLUMINATION.

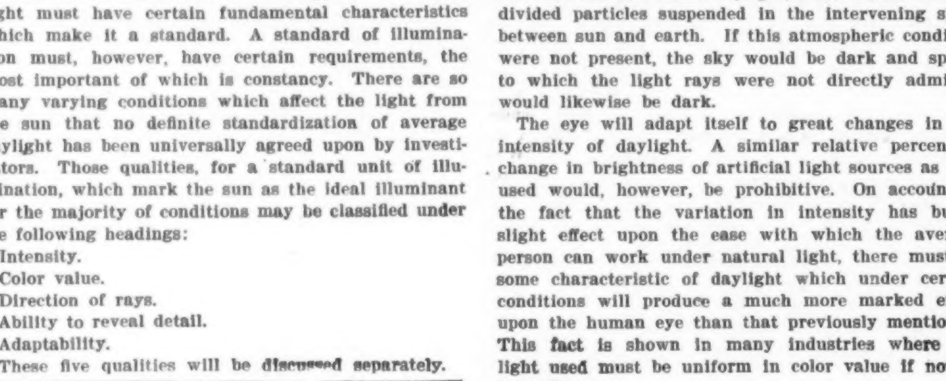
Referring to the first of the five qualities, we will consider the intensity of daylight illumination.

The sun is brightest at noon, i. e., the sun is at its maximum intensity, when there is the smallest chance for its direct days to enter the eye and injure the retina. The eye of man is naturally protected by the projection of the forehead, from the high intensity of the sun's light during the larger portion of the day. At sunrise and sunset, however, the rays of light of maximum intensity come in a horizontal direction and are therefore more liable to injure the delicate interior of the eye. The usual presence of mist or fog and the greater absorption due to an additional depth of atmosphere at the horizon decrease the brilliancy and give to the light a diffusion and color tone, which cause no injurious effect upon the eye. Although the principle of a light source varying to meet natural conditions cannot be applied to artificial illuminants, that of placing the light source above the range of vision, so that the natural construction of the eye may be utilized, is immediately appreciated.

The diffusion and reflection obtained in artificially-lighted rooms are far different from the effects obtained with sunlight or daylight. The height of interiors limits man in employing to the best advantage the principle of diffusion in planning artificial illumination.

Actual sunlight which has been referred to is a quantity unknown upon the earth. The source of sunlight is distant from the surface it illuminates by more than eleven thousand times the diameter of this surface. During the greater portion of the day about fifteen or twenty per cent of the total light received from the sun is diffused daylight, scattered from finely-divided particles suspended in the intervening space between sun and earth. If this atmospheric condition were not present, the sky would be dark and spaces to which the light rays were not directly admitted would likewise be dark.

The eye will adapt itself to great changes in the intensity of daylight. A similar relative percentage change in brightness of artificial light sources as now used would, however, be prohibitive. On account of the fact that the variation in intensity has but a slight effect upon the ease with which the average person can work under natural light, there must be some characteristic of daylight which under certain conditions will produce a much more marked effect upon the human eye than that previously mentioned. This fact is shown in many industries where the light used must be uniform in color value if not in intensity.



SHOWING NATURAL DIFFUSION OF LIGHT. UNCLOUDED SKY AND SUN AT MID-DAY.

Light is radiant energy which in the form of waves of different lengths affects the nerves composing the retina of the eye. These waves express themselves as different colors. Average daylight or so-called sunlight is a clearer and whiter light than that from any artificial lighting source thus far perfected. When allowed to fall upon a prism, however, it is immediately seen that this white light is composed of seven

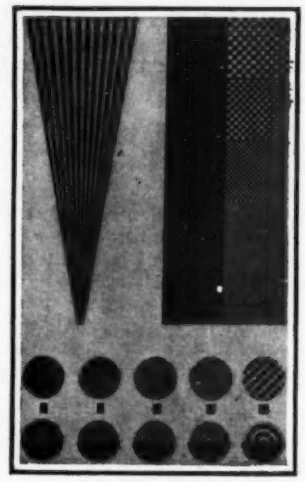


CHART FOR ILLUSTRATING VISUAL ACUITY.

By holding red, green or blue glass between eyes and chart, variation in sharpness of detail is shown.

visible and easily distinguished colors, namely, red, orange, yellow, green, blue, indigo, and violet in varying proportions. These colors are the seven fundamental or visible spectral colors which form a part of the total radiation from the sun. This wave radiation or emission from the sun affects the human sight only in that portion of the spectrum between the red and the blue limits.

The so-called infra-red and ultra-violet extremes of the spectrum, which lie on either side of these values of red and blue, form the larger portion of the radiation from artificial sources and, due to their wave lengths, they are lost to view. It can readily be shown that the most efficient illuminant would be one in which all of the radiation properly proportioned as to color would occur between the limits of red and blue, and therefore would be visible.

Daylight is composed of varying proportions of the seven visible colors. The greatest variation in the quality of daylight may be attributed to the varying percentages of these fundamental colors. A certain relationship in all kinds of daylight exists between the different colors which, when combined, form it. A proportion remaining practically the same under most conditions is that the amount of blue light in nature is maximum while the red is minimum. Such a proportion of the fundamental colors can be likewise noted in all growths in which the reds are produced to a less degree, while the blues and violets are always apparent. Other primary colors composing daylight vary in amount between the two limits. A similar statement is true for all forms of light radiation whether natural or artificial; in the latter, however, there does not exist the same proportion of fundamental colors as in any form of daylight.

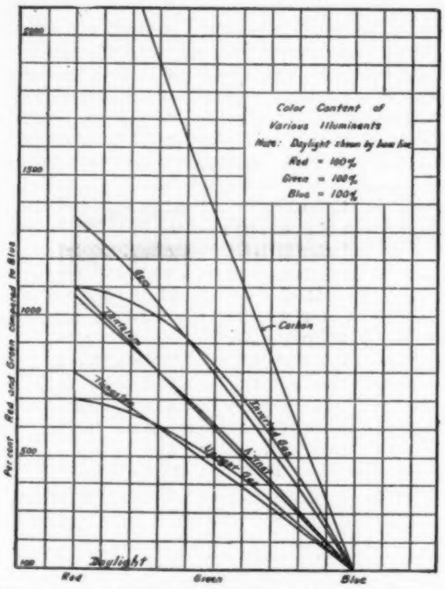
The following table gives the "Nichols" results for per cent of color in daylight. It expresses in percentages the results of measurements of daylight by Prof. Edward L. Nichols, as given in the Transactions of the Illuminating Engineering Society for May, 1908:

GENERAL AVERAGES.

Average.	Wave Lengths in Centimeters.					
	Red.	Orange.	Yellow	Green.	Blue.	Violet.
	$.725 \times 10^{-4}$	0.625	0.530	0.460	0.420	390×10^{-4}
For— Lower levels...	5.12	9.09	13.71	19.50	24.46	27.93
Higher levels..	4.14	8.48	13.37	21.62	26.90	25.43
All stations...	4.53	8.71	13.48	20.81	26.08	26.45

By exhaustive observation it has been found that any color of light can be duplicated by combining in various quantities three of the primary or spectral

colors, namely, red, green, and blue. In laboratory practice as well as commercially by the process of trichromatic photography, it is shown that color shades and tones can be correctly reproduced by the proper combination of these three instead of the seven colors. This principle has been embodied in an instrument invented by Mr. F. E. Ives and called the Ives colorimeter. It is an instrument which gives correct percentages of the three primary colors composing the light from any of the present incandescent light sources. In this apparatus the three primary colors of light are combined by a so-called color mixing device and allowed to fall on one-half of the field in the instrument, the other half being illuminated by the source under test.



PER CENT OF RED, GREEN, AND BLUE IN VARIOUS ARTIFICIAL ILLUMINANTS AND IN DAYLIGHT.

Daylight taken as standard and shown by base line.

By regulating the proportion of the three colors, Dr. H. E. Ives of the Bureau of Standards has duplicated the color of average daylight and has likewise made accurate determinations by this method of the proportions of the three colors comprising the light from many artificial sources. His results are given in a paper presented before the Illuminating Engineering Society. Several other investigators have likewise made measurements which show that the value of blue light composing the average daylight is much in excess of that obtained by Dr. Nichols.

As previously stated, the proportion of the three colors of light composing daylight is so variable that a standard for average daylight would be difficult to obtain. How variable this standard is may be more readily appreciated if one compares a series of colors as seen in the light of a north window with the same colors as seen at a west window in the light of the late afternoon sun. Not only do the natural conditions of the atmosphere produce such great changes in the color value of light, but it must be recognized also that certain conditions affect this quality as much or more than atmospheric changes. The causes of variation in the color of daylight entering any space may be tabulated as follows:

Causes involving the sky alone.	1. Clear blue sky. 2. Cloudy sky. 3. Overcast sky. 4. Natural conditions due to rain or snow. 5. Natural conditions due to dust or snow. 6. Artificial conditions due to smoke or chemical vapors.
Causes involving the surroundings.	1. Condition and color of surface of ground. 2. Trees, shrubbery or gardens in proximity. 3. Walls of adjacent buildings. 4. Character of windows or openings for the admission of light.

The color quality of light which enters any given space may vary in any of the three fundamental colors composing it as much as twenty to thirty per cent, according to changeable conditions of atmosphere and surroundings. For this reason, it can readily be understood that a standard of daylight has not yet been obtained, with which artificial illuminants may satisfactorily be compared.

The variations which have been mentioned allow of enough changes to take place to make daylight of different qualities unserviceable for some classes of interior work. There are relatively few art studios and shops where articles of a delicate color value are sold in which it is possible to make a proper comparison of color on all occasions. This is due to the many varying conditions affecting the quality of daylight which enters.

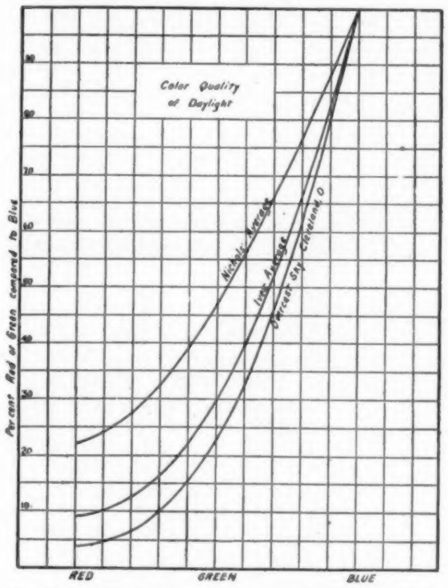
It is apparent that more consideration should be given to this characteristic of daylight when it is compared with artificial illumination. Not only should this condition be taken into account in art galleries and other locations where the color of decorations plays an important part in making the sales, but it should also be considered in home interiors, offices and other places where the color plays an important part in the harmonious appearance of surroundings. For instance, a man living in a city is much interested in the color which a neighbor paints his house, as it greatly affects the light received through his side windows. Decorative effects are greatly varied by the condition of the color of the surrounding buildings, etc., to such an extent that when the sun's light is reflected from a light colored surface such as a snow-covered ground or a white wall of a building, a flat indistinct appearance is given to interior effects. With an exterior ground surface of a soft color tone from which the light is reflected to an interior, the quality of light reflected produces a color effect which greatly improves the interior appearance.

DIRECTION OF RAYS OF LIGHT.

The directional relation of natural light plays a very important part in the general appearance of any surroundings. Maximum daylight is usually received in a plane approaching more nearly the vertical than the horizontal, causing shadows and high lights to appear in correct proportion. On the other hand an extremely flat effect would be caused by a light with almost complete diffusion, caused in nature both by the presence of suspended dust particles, clouds and many reflections from surrounding objects. A very similar effect is produced when the difference between the lights and shades is too highly accentuated as in the case of objects illuminated by a search-light.

It is seen from this that there is a necessity for directing light into such locations that there will be sufficient direct as well as diffused light to make a harmonious shading from high light to shadows without a marked change from one to the other. Shadows may be considered by some as unimportant, because it appears that a person can see almost as well in diffused sunlight, caused by clouds, as in direct sunlight.

On days when there is no direct sunlight there is considerable shadow, but there is a less sharp contrast between light and shade because of the gradual character of the change. Were it not that shadows are always present, the work of the architect would not appear very artistic, particularly in exterior work. In interiors the numerous windows acting as light sources cause complex shadow effects, making the problem of illumination with the proper proportion of light and shade more difficult. The adoption, however, of the principle of taking exterior conditions into account, would, no doubt, have a marked effect. Shadow depends upon direction of light. If the lower, or less illuminated portion of an object as seen in daylight were thrown into the light, and the upper or more illuminated portion, in the dark, the object would be almost unrecognizable. Reverse the condition, and it at once stands out in detail. With perfect diffusion, however, we have none of this light and shadow effect, which makes an object plainly visible.



CURVES SHOWING PER CENT OF RED AND GREEN LIGHT IN DAYLIGHT.

Blue taken as 100 per cent in all cases.

This question of having the proper direction of light in order to make objects visible, invisible or of revealing detail has a direct bearing on the question of visual acuity. The color value of light in making possible fine distinctions of detail plays a more or less important part in the physiological effect produced upon the eye. It is found in daylight that a person doing work which requires a proper consideration for fine lines and detail will not depend upon the direct light from the sun, but will in all cases seek a diffused illumination. This may be obtained in a shadow or from a portion of the sky, which is not the brightest. In reading, a person will always prefer the light obtained from a window, which is not receiving direct

CORRECT APPEARANCE OF OBJECTS AS ILLUSTRATED BY SHADOWS.

INCORRECT APPEARANCE OF OBJECTS WITH ALL SHADOWS REVERSED. (NEGATIVE OF JUXTAPOSED ILLUSTRATION.)

rays of the sunlight unless a shade or curtain of some kind obstructs the direct rays and softens them in intensity and color value. It is true that different eyes are affected differently. Some require more light of one quality than others, but in the majority of cases it must be noted that light, for proper purposes of reading or fine distinction, will be within certain limits, and must likewise be of a certain quality and diffusion to allow the least possible direct light to enter the eyes of the observer.

In dealing with the subject of visual acuity or power of revealing detail, with lights of different color value, the effect of large light variation must be considered. Most commercial sources of light due to slight causes vary so greatly in their individual characteristic color quality that it is found necessary, in order properly to designate the best light for given purposes, to turn to the primary colors and note which is best.

Most people find themselves short-sighted for the light from the blue and violet ends of the spectrum. For the power of revealing fine detail with an accompanying ease of sight, the blue and green lights are to be preferred to the red for short distances. By looking through red, green and blue glass at the chart this point can be easily observed. The red, on the other hand, is preferred by the majority of persons for revealing details at a greater distance. Keeping this principle in mind, it can readily be seen what an unsatisfactory effect would be produced if a red or blue-violet light were to be used for general illumination purposes. The important requirement for a light is then to be able to distinguish color values, fine detail, etc., with the proper intensity and direction, whether it be daylight or artificial light. The qualities of efficiency and steadiness of light production apply more directly to artificial sources of light than to that of daylight. These qualities may be grouped beneath the heading of adaptability, inasmuch as all light should be readily adaptable to meet various requirements.

ADAPTABILITY OF LIGHT.

The light from the sun was primarily used for purposes of mechanical labor where the necessity of revealing fine detail, obtaining proper color quality and intensity were not required to such a great degree as they are at the present time.

On account of the requirements which have been developed in the progress of civilization, daylight has failed to answer for all purposes, due to the fact that our vocations must be pursued at all times without depending upon daylight. For this reason the adaptability of all sources of light, including both natural and artificial, must be given proper consideration.

On account of requirements it has been necessary to use prismatic glass and to adopt an entirely new construction of building and skylights, in order to use natural daylight for such classes of effort as are generally undertaken for manufacturing and industrial purposes. It is true that artificial illuminants must be adapted for more diverse purposes than daylight. They must likewise be directed in such a manner as to meet all interior requirements. Practically all commercial illuminants have been designed with this thought in mind. The ideal light source, on the other hand, must have such qualities of color and ability to reveal detail, such intensity and direction of maximum rays as to make it capable in all conditions of service to meet certain requirements depending on the conditions surrounding the work for which they were intended.

ARTIFICIAL ILLUMINANTS.

Having discussed the various characteristics of daylight in comparison to artificial light relative to the previously mentioned qualities, we will make a few direct comparisons. The characteristic qualities of daylight will be compared with the similar qualities of the following illuminants in an endeavor to determine from the standpoint of adaptability which is the best for given conditions:

1. Carbon treated filament lamp.
2. Carbon untreated filament lamp.
3. Gem metallized filament lamp.
4. Tantalum filament lamp.
5. Tungsten filament lamp.
6. Nernst lamp.
7. Inclosed arc.
8. Upright gas arc.
9. Inverted gas arc.

The light flux of all these lamps is vastly different. The brilliancy of any of them is so far below that of the sun that the impossibility of obtaining comparisons in intensity between them and the sun is readily apparent.

In referring to the intensity of the light sources investigated, the advisability of placing a light source of high intrinsic brilliancy a sufficient height above the floor level of any space, in order to benefit by the principles previously noted regarding the sun, is self-evident. An alternative, likewise possible, is to reduce the intrinsic brilliancy of the source by using glassware of proper design and intensity to increase the diffusion of light and to decrease its brilliancy. By the use of this principle, the necessity of resorting entirely to height in order to produce a sufficient diffusion of light is eliminated.

The question of the color value of given commercial light sources is one which has caused more diverse opinions to be raised than any other quality of artificial illuminants. All artificial light sources have a characteristic quality of color which is apparent from observation. The colors of the investigated illuminants may be listed as follows:

	Designation.	Color.
1.	Carbon, new	Yellow.
2.	Carbon, seasoned	Orange-yellow.
3.	Carbon metallized, new	Pale-yellow.
4.	Carbon metallized, seasoned	Yellow.
5.	Tantalum, new	Yellow-white.
6.	Tantalum, seasoned	Lemon-yellow.
7.	Tungsten, new	Cream-white.
8.	Tungsten, seasoned	Yellow-white.
9.	Nernst Lamp, new glower	Pale-lemon-yellow.
10.	Nernst Lamp, seasoned glower	Deep-lemon-yellow.
11.	Inclosed arc, opal outer, clear inner globe	Bluish-white.
12.	Gas arc upright, new mantle	Pale-greenish-white.
13.	Gas arc upright, seasoned mantle	Pale-greenish-yellow.

The colors of these sources are not readily apparent when used for general illumination purposes. Nevertheless, when a given series of colors is viewed beneath the light from any one of them the effects produced vary a great deal from the true color values as seen under daylight illumination.

The true importance of obtaining the best form of illuminant in order to give the most desirable and attractive results for all classes of service may be observed when a comparison is made between the color effects produced by the illumination from artificial light sources in comparison with that of daylight. A surprising advance has been made in the incandescent lamp industry in the endeavor to obtain a type of lighting unit which would cause objects to appear more nearly natural under artificial illumination.

Not only for store lighting, but likewise for residence lighting the production of the proper color values and of the proper intensity and direction of light to give a pleasant appearance to interiors should be the general aim for all users of artificial light.

Not only from the standpoint of the merchant, but likewise from that of the architect, the interior decorator and furnisher, there is the necessity for obtaining the best means to advance his efforts in artistic lines. This view should not be limited to mere financial ends for the use of light, but a lasting benefit should be gained by improving the standards for all classes of human effort in art and decoration as well as commercialism.

It has been shown that from the standpoint of direction of light there must be, for satisfactory illumination, not a complete diffusion, but a balance giving the proper proportion of light and shade.

Esthetic tastes are sometimes appealed to by an incorrect use of illumination, in order to impress the observer with the beauty of surroundings. A more useful result would, however, be obtained by making the most practical efforts to impress the user of artificial light with the necessity for living and working to his best advantage under conditions requiring the use of artificial light. Owing to the inability of natural light to meet our modern requirements for constancy of intensity, color value, etc., it is obvious that artificial light sources correctly applied must be adopted.

It has been shown that some of the investigated sources are better for one condition of service than are others. It must be concluded that the best artificial illuminant upon the commercial market at present is that which is adaptable to the largest number of classes of service, provided that it maintains a high standard of the afore-mentioned qualities of light.

The importance of obtaining best possible illumination can be better appreciated when it is considered that, at the present time as never before, there is in the minds of most people a broader comprehension of what constitutes good illumination.

The five qualities of the ideal lighting source should not be overlooked, for many thousands of dollars are spent annually on the production of pleasing lighting effects. If these can be improved and the art of illumination placed upon a higher plane, we are greatly benefiting humanity.

OXIDATION IN SOIL-FERTILITY.

The rôle of oxidation in soil-fertility is discussed by Oswald Schreiner and Howard S. Reed in a bulletin which has recently been issued by the Bureau of Soils of the Department of Agriculture. The results of the investigation show that roots of growing plants exhibit intercellular oxidizing power which may be demonstrated by the use of suitable chromogens in nutrient solutions or soil extracts. The oxidizing power appears to be most energetic in the region of the root where root hairs are found, and to decrease gradually in activity as that portion of the root becomes older. The oxidizing power of plants grown in extracts of productive soils is greater than that of plants grown in extracts of unproductive soils. Treating the soil extracts with an absorbing agent is usually beneficial to oxidation. The distillate of a poor soil extract which contains volatile toxic compounds was less favorable to oxidation than the residue remaining from distillation. The process of oxidation is usually accelerated by the addition of nitrates to an aqueous soil extract. The addition of ammonium sulphate is less beneficial to oxidation than the addition of an equal amount of nitrogen in the form of nitrate. Calcium salts were found to increase the amount of oxidation in cultures to which they were added. The addition of potassium salts was not generally beneficial to the process of oxidation. In some cases their presence caused a material retardation of the oxidation. The most of the retardation was due to the action of the potassium itself and not to the formation of acid conditions in the solution. Sodium or ammonium salts of the same acid were more favorable to oxidation than the corresponding potassium salt. Phosphates usually produced material increases in the oxidation in solutions to which they were added. Chlorides and sulphates, when combined with a suitable base, like sodium, are somewhat beneficial to oxidation, but are not as favorable as the corresponding nitrate would be.

The presence of toxic organic substances in solution was extremely deleterious to the oxidizing power of the plants. The oxidizing power of the plants, especially in the presence of nitrates, was able to alleviate the toxicity of such solutions.

The process of oxidation by roots is largely, if not entirely, due to the activity of a peroxidase produced by the roots. This oxidizing enzyme is most active in neutral or slightly alkaline solutions. The activity of the enzyme may be inhibited by the presence of acid and also by the conditions in solutions where putrefaction processes occur. This oxidation by roots has considerable agricultural interest, since processes promoting oxidation play a large part in the best methods of soil cultivation and tillage.

CO-OPERATION TO PREVENT FOREST FIRES.

Secretary of Agriculture Wilson has signed an agreement with the Great Northern and Northern Pacific roads, says The Railway and Engineering Review, which provides for co-operation of the forest service and railroads to prevent damage to national forests from fires. The companies agree to clear and keep clear of inflammable material a strip of varying width, as conditions may demand, up to 200 feet beyond the right-of-way and to provide all locomotives which do not burn oil, with suitable spark arresters and other standard equipment to prevent the dropping of fire. In fighting fires, railroads and the forest service will co-operate closely. Prompt notification to forest officers of all fires discovered by employees of the railroads is provided for. Telephone lines to make this possible will be put up by the forest service, using company poles where this is desirable. Warning whistles will be sounded by locomotives on occasion. Forces of fire fighters will be assembled on the outbreak of fires, made up of forest officers, railroad employees and such temporary labor as can be gathered by either. Except for salaries of regular employees the cost of fighting fires which start within 200 feet of railroads will be borne by the railroads, and the others by the forest service. The agreement provides that the forest service will regularly patrol the rights-of-way during a fire season.

In the course of an interesting paper on "The Progress of Electric Braking on the Glasgow Corporation Tramway Service," read by Mr. A. Gerrard before the members of the Institute of Electrical Engineers, the author said the Glasgow Corporation Tramways Department was at present engaged in fitting to each car an automatic sanding apparatus the component parts of which were a solenoid, and a continuous flow sand valve. The coil of the solenoid was inserted in the main breaking circuit, and its armature was connected to the continuous flow sand valve, so that when the solenoid operated the sand valve was opened, and a copious supply of sand was projected on the rail without any effort from the motorman. A spiral spring was attached to the valve in such a way as to work against the action of the solenoid, and adjusted so that if the electric brake was applied for an ordinary service stop or for coasting, the solenoid was prevented from opening the valve and serving out the sand when it is not required, but in the event of the motorman making an emergency stop, the current flowing through the circuit was sufficient to operate the solenoid and automatically to supply sand at a most opportune moment.

THE LATE SIR WILLIAM HUGGINS.

A PIONEER ASTROPHYSICIST.

THE death of Sir William Huggins, which took place in London on May 12th, closes a long life of useful activity devoted to pure science, a life full of recognition and honors. If official recognition of his merits came late in his life—as it often does in this country, as well as in others—official honor was finally meted out in full measure, while his fellow-scientists had from the first paid tribute to the distinguished work in astronomy and solar physics accomplished by an earnest worker who was not a professor, not connected with any of the great national institutions, nor even a graduate of any English university, all his degrees being honorary. He was in his seventy-fourth year when the Order of the Bath, together with the knighthood, was conferred upon him on the occasion of the Queen's Diamond Jubilee; in 1902 the late King made him one of the twelve original members of the Order of Merit. The Royal Society elected him a fellow in 1865, two years after the presentation of his first paper; honorary degrees, medals, and other distinctions followed, and in 1900 Sir William Huggins succeeded Lord Lister as President of the Royal Society. As such he presided over the inauguration of the National Physical Laboratory by the present King and Queen, while the numerous foreign distinctions awarded to him testify to the general esteem in which he was held all over the world.

William Huggins was born in London on February 7th, 1824, and was thus in his eighty-seventh year, when he died after an illness of only one day. He was educated at the City of London School and at home. Private tutors instructed him in classics, mathematics, and science, and it must not be thought that the Royal Society somewhat deviated from its custom by offering the presidency to one of their members who had confined his studies to one branch of science. Young Huggins, in fact, was long in doubt whether he should take up physiology and microscopical research, or pursue his life study chiefly with the aid of the telescope. His decision in favor of the telescope came at an opportune period. It was only a few years after he had been able to erect a telescope of his own at Tulse Hill, in 1856, that Kirchhoff and Bunsen published at Heidelberg, in 1859, the researches which at once put spectrum analysis on the footing of a novel and most important means of investigation. Many physicists, like Kirchhoff and Bunsen, began to examine the sun; others went further and sought to ascertain whether the starry world gave evidence of containing the same constituents or some of them which it was then known or believed made up the earth and sun. In this work Huggins collaborated with his friend, W. Allen Miller, professor of chemistry at King's College. A star spectroscope did not then exist, of course; it had to be created. The light of the stars is exceedingly weak, and the identification of the lines of the spectrum with the instruments then available was most difficult. Progress was, in fact, in the first years of stellar spectroscopy, as Sir William Huggins himself later remarked, "much retarded by resting important conclusions upon the apparent coincidence of single lines, in spectroscopes of very small resolving power."

By 1863 Huggins and Miller presented their first joint paper to the Royal Society, a "Preliminary Note on the Lines of Some Fixed Stars." The very day, it is said, that they read this paper they were informed that Rutherford, in the United States, and Secchi, in Italy, were engaged in similar work. The question of priority was hotly contested, not by the chief workers, but by their friends. Huggins never was the man to speak of his own achievements. His modesty could not but strike even the most casual acquaintance. But his friends felt all the more called upon to urge his claims. The whole controversy was futile. It would, indeed, have been astonishing if stellar spectroscopy had been initiated without some such coincidence, and in fact one cannot now help wondering a little that the discovery of spectrum analysis should have lain dormant so long a time. In stating this we do not in the least desire to deprive Kirchhoff and Bunsen of the credit which is so justly accorded to them for their remarkable systematic investigation. A few words will explain our reasoning. Fraunhofer himself wrote in 1817 that, to judge by the (Fraunhofer's) lines, the light of Venus and of Mars was that of the sun, while the light of Sirius differed; in other stars, moreover, he observed different bands in 1821. J. F. Herschel stated in 1835 that the series of "fixed lines" in the spectrum of stars like Sirius was totally different from that of any known terrestrial flame. The elder Herschel had observed in 1823 that the yellow sodium flame was characterized by a yellow line, and it was apparently the ubiquity of this line which prevented him and others from following the problem up. Still more noteworthy is Wheatstone's report of 1835 to the British Association, in which he describes the lines seen in an electric spark when striking into mercury; there were the two D lines, one green, one blue, one indigo, one violet line, and sparks from other metals, he noticed, gave other lines.

Continuing their studies, Huggins and Miller examined in their laboratory the puzzling differences between the spectra obtained under different conditions. One of his later successful researches, carried out in conjunction with Lady Huggins, who, after his marriage in 1875, had become his able and enthusiastic assistant and joint-author of his memoirs, should be mentioned in this connection. It had been noticed that the general sun spectrum displayed seventy-two calcium lines, while in the spectra of the chromosphere and of the prominences, only two lines could be attributed to calcium. That discrepancy was so strong that the whole identity of the solar calcium lines was questioned; everybody is aware what an importance is attached to calcium vapors in the solar atmosphere. In 1897 Huggins established that at sufficiently reduced pressure the number of calcium lines was, indeed, diminished to two. This difficulty having been cleared up, spectro-photography in calcium light could take its established position.

Stellar spectro-photography had been attempted by Huggins in the early sixties. But the imperfection and unsuitability of the old silver plates and of the wet collodion plates, which were then alone available, baffled his endeavors. When he resumed this branch in the seventies, the gelatine-bromide plate—almost perfect, apart from its grainy texture, as he remarked in his presidential address to the British Association at Cardiff in 1891—had been invented, and, thanks to the interest that the Royal Society took in his work, he was in possession of a 15-inch refractor and an 18-inch reflector, fitted with mirrors of speculum metal, besides a spectroscope provided with quartz lenses and prisms of Iceland spar, which did not stop the ultra-violet rays. Thus he was able to study the spectra of stars with a view to their classification, as proposed by Secchi in 1863, and modified by H. C. Vogel in 1874. The order in which Huggins arranged the stars from their photographic spectra in 1879 was essentially that of Vogel—to quote Huggins's own words. Soon afterward he was able to show that the star-like nuclei in the Orion nebula really belonged to the nebula, and were not in front or behind the nebula.

He had been studying nebulæ since 1864, and had been able to decide whether nebulæ were to be regarded as portions of the fiery mist or shining fluid, out of which, in the elder Herschel's words, the heavens and the earth had slowly been fashioned, or whether they were external galaxies, cosmical "sand-heaps," too remote to be resolved into separate stars. The spectrum of the nebula in Draco proved to be the bright line spectrum of a glowing gas upon a background of a faint continuous spectrum. Turning his attention to the spectrum of comets, Huggins found carbon vapors in it, thus confirming a suggestion thrown out by Donati in 1858. Laboratory experiments on olefiant gas and other hydro carbons confirmed Huggins in his opinion that hydro carbons were to be found in the constituents of comets. When delivering the Bakerian lecture in 1885, Huggins regarded the corona of the sun as similar in the cause of its formation to the tails of comets—that is, consisting for the most part of matter going from the sun under the influence of some force, probably electrical. Many of the corona particles might return to the sun, but those forming the long streamers did not return, and diffusing they might, he suggested, go to furnish the matter also of the zodiacal light. The cometary matter he considered identical with that of meteorites.

One of the signal triumphs of the work of Huggins was his application of the Doppler principle to the study of the motion of stars in the line of sight. In his original paper on "Das farbige Licht der Sterne," published in 1841 at Prague, Doppler had suggested that the difference in color observed in some binary stars might be produced by their motion. Doppler was right in so far as the principle is as true in the case of light as it is in the case of sound; but he was wrong in supposing that a change in color could actually be recognized, even if the star were moving with such an enormous velocity as to alter sensibly its color to the eye. Huggins understood that the principle became applicable as soon as lines of known substances had been recognized in stellar spectra, and his first observations of 1868 were soon confirmed by Vogel and Scheiner at Potsdam, by Christie at Greenwich, and later by Keeler at the Allegheny and the Lick observatories. The latter was also so fortunate as to measure, with the magnificent instruments at his disposal, the motion of planetary nebulæ in the line of sight. How greatly this important method of research has since been developed by able observers on both sides of the Atlantic is now well known.

Huggins also was a pioneer in solar physics. The suggestion that it would be possible to observe solar prominences any day—not only during solar eclipses—with the aid of the spectroscope was due to him. The idea was that the spectrum of the prominence would be sufficiently bright, while the prisms would disperse the air-glow. Huggins also suggested—and Zoellner at the same time—that if a wide slit were slowly removed from the limb of the sun, the prominence would record its own width at different distances from the limb, and thus its shape. The first actual observations of this kind were secured by Janssen in 1868.

When the phenomena of radioactivity were investigated early in this century, Huggins took up the spectroscopic side of the problem. We cannot, however, further specify his work on the present occasion. That he continued to excel is best proved by a long series of distinctions conferred upon him. The Order of Merit, which we have already mentioned, he valued highest. The Royal Society, which admitted him in 1865, awarded him a Royal Medal in 1866, the Rumford Medal in 1880, and the Copley Medal, the highest honor at its disposal, in 1898. The Royal Astronomical Society, whose president he was in 1876, had given to him and to Miller a gold medal in 1867. Honorary degrees had come from Cambridge in 1869 when he was Rede lecturer, and from Oxford soon afterward. The Paris Academy awarded him the Lalande Prize for astronomy in 1872, and the Prix Janssen of the Institut fell to him in 1888. He also held the Wilde and the Draper Medal, and the Medal of the Pacific Astronomical Society. During his presidency of the Royal Society in 1900 to 1905 he accentuated the value of the study of science against the advocates of humanistic studies, and selection from his presidential addresses to the Royal Society were published in 1906 under the title "The Royal Society, or Science in the State and in the School." His most important works are the "Publications of Sir William Huggins's Observatory," of which the first volume, entitled "An Atlas of Representative Stellar Spectra," appeared in 1899, while the second volume, "The Scientific Papers of Sir William Huggins, K.C.B., O.M.," was published only last year.

In 1875 Sir William Huggins had married Miss Margaret Lindsay, daughter of Mr. John Murray, of Dublin, herself a great astronomer and joint-author with him also of the atlas just mentioned. A man of a happy, humorous disposition, very fond of children, whom he delighted to interest by simple demonstrations, Huggins became more retiring and reserved in his older days. He had the true modesty of the true scientist, ready to advise and to help fellow-workers, and he was a man of high culture. Sufficiently endowed with means to live in comfortable circumstances, he possessed quite a noteworthy collection of early Italian art treasures, and built himself a pneumatically-driven organ. The instruments which the Royal Society had intrusted to him were in 1908 offered by him to the Cambridge Observatory, and were at once accepted. He spent all his life practically at Tulse Hill. The end came as suddenly and from the same causes as that of King Edward, within less than a week of the King's death. The funeral took place on Saturday last, the 14th inst., his remains being cremated at Golder's Green. Lady Huggins survives him; he leaves no children.—Engineering.

BRENNAN MONORAIL SYSTEM FOR ALASKA.

IT appears that the first practical application of Louis Brennan's gyroscope monorail car is to be made in Alaska, where a system of monorailroads will be built connecting several camps. Exclusive rights to use this car in Alaska have been granted to an American syndicate, represented by J. E. Ballaine, of Seattle, Wash., and a firm of New York bankers. The syndicate has agreed to build one hundred miles of railway within one year following the completion of two cars, an order for the construction of which has been given to Louis Brennan, in London. Mr. Ballaine is quoted in reports as follows: "I estimate the cost of the 100 miles of line we are going to build from the Matanuska coal fields toward Fairbanks will not exceed $3,000 a mile, compared with at least $20,000 for even the lightest double-rail track."

ATMOSPHERIC ELECTRICITY.*

A REVIEW OF OUR PRESENT KNOWLEDGE.

BY ELIHU THOMSON.

THE study of the nature and origin of electrical storms or disturbances throughout the atmosphere is of much interest; our knowledge is yet meager; there is much more yet to be learned in this fascinating field. Exploration of the electrification of the air at varying heights by captive balloons, by kites and upon elevations of land, has generally shown an increasing electric potential upward from the earth, and usually positive in relation thereto. Sometimes this relation is reversed. It has been roughly estimated that if the differences noted can be assumed to be extended to include the total depth of the atmospheric layer, the earth's surface might be negative to the surrounding space, 150,000 volts more or less. This condition would not admit of being regarded as constant or stable, since widespread electric storms occur in both our upper and lower air levels. In the highest regions of our atmosphere they take the form of diffuse dis-stream, an aurora may be produced. During a total solar eclipse the so-called coronal streamers are seen to extend from the sun's surface to distances of upward of two millions of miles or possibly farther than that, but doubtless they keep on outwardly, and invisibly, to relatively enormous distances. It is not unreasonable as a hypothesis to imagine that they may extend at times as far as the orbit of the earth and may, if the direction is the proper one, reach our outer air.

Further, if they consist of electric ions or particles conveying electric charges, an aurora may result. Dr. Hale, of Mount Wilson Observatory, has indeed recently shown by the spectroscope that great solar storms are in fact attended by the motion of electric ions at enormous velocities. The phenomena of auroras present peculiar difficulties in their study, since, as in the case of the rainbow, no two observers at a distance from each other see the same or identical appearances. Hence attempts to determine the height by triangulation at which auroras exist give most contradictory results, for it is impossible to fix upon any condensation or streamer which may not be displaced or absent to another observer some distance away. This is understood when we bear in mind that the luminous appearances are not located in one plane, but are distributed in space; condensations of light being the result of superposition in the line of observation.

I have come to the opinion that the auroral streamers often extend in a general direction outwardly from the earth, sometimes to very great distances relatively to the known extent of our atmosphere. The effects observed appear unaccountable upon any other supposition, while they are consistent with the idea of outwardly directed streams of great extent. In April, 1883, there occurred an aurora which was at its maximum a little after midnight. It was the most magnificent display of the kind which, in spite of a continual vigilance on my part, it has been my fortune to witness. It was upon such a scale that, so to speak, the mechanism of the streamers stood revealed. At that time I could not avoid the conclusion that the auroral streamers must have extended outwardly several thousand miles. There is no space here to present the argument involved. Perhaps the most significant fact is that precisely the same general appearances were noted in Chicago as in the East, and that they occurred simultaneously. The interesting question arises, Does the earth temporarily acquire streamers similar in nature to the solar coronal streamers? The answer is as yet unknown. At the time of the great display mentioned there was a sunspot near the center of the sun's disk of about 50,000 miles in diameter. During that disturbance long telegraphic lines could not be operated, owing to the arcing at the keys which prevented interruption of the circuits. Apparently in subtle sympathy with its master orb, the sun, the earth's electric and magnetic equilibrium was for a time profoundly disturbed.

While it is by no means certain that auroras and magnetic storms are always dependent on solar outbursts, it is now generally recognized that the observed coincidences are too frequent to be the result of chance. It is perhaps safe to assume that although solar storms and sunspots can occur without provoking auroras or magnetic storms here, it may be doubted if these latter occur on any great scale unless solar activity is coincident therewith. And it seemingly is true that only when the projected electrified matter actually reaches the earth or comes near enough to inductively affect its electrical equilibrium are the terrestrial phenomena produced thereby.

STUDY OF AN AURORAL CURTAIN MADE ON JULY 5, 1902 (1 H. A.M. TO 2 H. A.M.) DURING THE NATIONAL ANTARCTIC EXPEDITION (1901).
Reproduced by permission of the Royal Society of London.

charges as in a high vacuum and are called auroras. They either accompany or give rise to magnetic storms, which affect the direction and intensity of the earth's magnetism temporarily, and hence disturb the compass needle, sometimes through many degrees.

The frequency of auroral phenomena, and perhaps also to some extent the frequency of thunder storms, seems to keep pace with the sunspot period, at least in our latitudes. At times of sunspot activity, the surface layers of the sun, upon the energy radiated from which so much of earthly activity depends, are stirred by great storms, or immense cyclones of hot gas or metallic vapors; storms seen as dusky spots on the sun's disk. They can attain enormous size—20,000, 30,000 or even 50,000 miles in diameter, though these dimensions are exceptional. They are visible, as is well known, not because they are non-luminous, but because they are less luminous than the surrounding solar surface. In like manner bright spots or faculæ may also be seen, because they are on the whole brighter than the sun's surface adjoining them.

There is much reason to believe that, in accordance with suggestions made many years ago, these solar storms are accompanied by exceptionally vigorous projection outward from the sun to immense distances, of streams of electrified matter. Should the earth happen to be in a position to be swept by such a

It has even been suspected that a greater frequency and severity of thunder storms in our lower air accompanies the active period of the sun on sunspot maximum. This is a hypothesis which would require a careful collection and comparison of data over a long period to give it status as a scientific fact or wholly to disprove it. Be that as it may, experience with lightning damage in electric installations seemingly supports the idea, and led me in a paper given some seven or eight years ago during the minimum period, to predict a severe ordeal a few years in advance. As a matter of fact the prediction was to a large extent verified with the result of extraordinary activity in devising safeguards from which the electrical engineering art now benefits. In general the harm done by thunder storms is due directly or indirectly to the heavy spark discharges called lightning flashes or strokes of lightning.

It may be of interest to refer briefly to the conditions existing in a cloud which is the source of such destructive energy. As is well known, clouds consist

* Abstract of address at the formal opening of the Palmer Physical Laboratory at Princeton University.

of fine water particles suspended in the air. When frozen these particles are crystalline like minute snow crystals. All clouds above the snow line are likely to be of that character. At a temperature above freezing the particles of water are microscopic spheroids

ANTARCTIC AURORAL STREAMERS.

which may by gradual coalescence form drops of rain. This process of coalescence necessarily diminishes the total surface of the water existing as such in the cloud. Should, however, the original particles possess even a slight electric charge, the union of the drops, by lessening the total surface, or diminishing the electric capacity, results in a great rise of potential or electric pressure on the surface of the drops. The process of coalescence continues and the water falls out of the cloud as rain. If the cloud particles are frozen the diminution of surface and consequent increase of electric pressure cannot take place. This would seem sufficient to account for the general absence of thunder storms in winter, though perhaps other causes contribute.

A thunder cloud has been compared to an insulated charged conductor, such as a body of metal hung upon a silk cord, but in reality the two are not at all comparable. It is a mistake to assume any close analogy to exist. The cloud being only an air body containing suspended water particles, is not a conductor, nor can it, as in the case of metal, permit the accumulation of its electric charge on its outer surface. In fact it possesses no true definite outer surface, but blends with the clear air around it. The electric charge it possesses remains disseminated, so to speak, throughout, and must reside chiefly upon the surface of its constituent water drops. Accumulation in any part would require the insulating air between the drops to be overcome.

A lightning stroke from such a mass may indeed represent a discharge of hundreds of amperes at millions of volts. We must, however, be cautious not to exaggerate either the current or the potential present in a lightning flash. The current in a flash can at times be only a few amperes or may in the heavier discharge reach perhaps hundreds, or possibly in extreme cases some few thousands of amperes. It is doubtful if the potential much exceeds at any time more than a few million volts as it is probable that small local breakdowns start the disruptive process which then extends through miles of length. The individual water particles even when collected into drops cannot be charged to such enormous potentials as millions of volts. In reality it is the combined effect of the numerous particles acting inductively that accounts for such pressures. A combined stress is set up toward the earth or toward another cloud mass of opposite charge. The lightning stroke results from a breakdown of the insulating air layer between them, and also all through the cloud itself, and for a time a partial neutralization or electric equilibrium is effected. This continues until a further redistribution of charges is required and until again the breakdown potential is reached. The continued coalescence of charged water particles which were not discharged at the first breakdown, repeats the original condition, and so on. Unlike the case of a suspended charged metal body, a single discharge does not usually equalize the electric potential of cloud and earth. Instead, many successive discharges occur. It is probably fortunate for us that the process is as gradual as it is, for the ordinary partial discharges of the cloud are each terrific enough and tax our resources sufficiently when we seek to protect ourselves and our effects from them.

Various hypotheses have been proposed to account for the presence of electric charges in cloud masses, but there is no time to discuss them here, and there is in fact little that is really known as to the origin of the electricity of clouds. We shall briefly refer to the phenomena which characterize or accompany the electric discharges. The usual form which the discharge takes is that known as disruptive spark or fork lightning, a long flash or electric spark, joining earth and cloud, or cloud and cloud, and branching within the cloud mass like a tree. Oftentimes between cloud and earth there is seen the single streak zigzag in its course, but within the cloud it ramifies or branches extensively in several directions. In this way only can any considerable part of the cloud contribute its portion to the main discharge path, for, as stated before, the cloud cannot act as a conducting body.

Some authorities treat lightning as a discharge of very high frequency like the ordinary discharge of a condenser or Leyden jar. In fact it has not been unusual to assume that such apparatus can be substituted and inferences drawn as to the nature and character of the lightning discharge from experimentation and tests with these laboratory appliances. There is, however, abundant reason to doubt that lightning discharges are really oscillatory. If they oscillate, the conditions are such as to forbid such oscillation being of a high frequency order. The cloud discharge represents what is known as a discharge of a large capacity, and the length of the path or spark may reach thousands of feet or even many miles; a long inductive path, while the heat and light given out in every part of the path indicate a high resistance to the passage of the discharge. All of these conditions are together known to be inconsistent with the idea of high frequency oscillation. But the breakdown or discharge is extremely sudden and involves an almost instant rise of the current to a large value, so that the inductive effects upon surrounding structures, such as electric lines or circuits, are very energetic and sharp like a quick blow struck; and these lines or structures become the seat of rapid vibration or high frequency oscillations. The sudden blow of the hammer on a bell in like manner brings out all the rates of the vibration, fundamental and overtones, of which the bell is capable and in which the hammer itself takes no part.

The very sudden startling character of a lightning discharge leads to an exaggeration in the popular estimate of its more evident effects. The amount of light given out is not so great as is often assumed. It does not give effects at all comparable with full sunshine. While doubtless the intrinsic brilliancy is very high, the duration of the flash is small, generally only a minute fraction of a second. In photographs of lighting the landscape is generally seen only in outline or poorly lighted by the discharge. In the daytime, when the clouds are not dense enough to greatly darken the sky, the flash loses most of the blinding character it

A REMARKABLE DISPLAY OF LIGHTNING.

has when seen in the blackness of night. Similarly, the sound of thunder, though of terrifying quality, is not extraordinarily loud. It is a common experience when traveling in a train to note that the sound of even near-by flashes is smothered by the roar of the train so that no thunder is heard. The noise of thunder cannot be due in any part, as is sometimes erroneously assumed, to collapse of the air upon itself and into a partial vacuum left by the spark. I have seen this error even recently repeated and even extended to include all the noise of thunder as due to such collapse. When, however, we consider that in a minute fraction of a second the air in the path of the discharge is so highly heated that, if it were confined, its pressure due to heat expansion alone would rise to more than ten atmospheres, we can readily understand the explosive shock given to the surrounding air and the propagation therethrough of an intense air wave. In fact such waves from electric spark discharges and from dynamite explosions have been clearly recorded by photography. Moreover, that the collapse of the air after expansion can have little or no effect in the sound production, follows from the fact that the heated gas streak left in the path of the discharge takes an appreciable time to cool on account of its low radiating power. This is shown by the observation that a lightning discharge in dusty air is often succeeded by a luminosity of the streak which persists for a perceptible time and slowly fades away like the luminous trail of a meteor.

Another common misconception is that the prolonged rolling character of thunder is due to reverberations or echoes. In mountain regions with steep rock walls such reverberations possibly contribute to the effect, but it is now clearly recognized that a sufficient single explanation suffices for most cases. Owing to the great length of the lightning spark or path, we receive the sound from the near parts of the discharge far in advance of that from the more remote portions, and between these sounds are those from parts of the path at intermediate distances from the observer. It follows from this that no two observers at a distance from each other hear the same succession of sounds in the thunder of a discharge. Whenever portions of the discharge path are situated or extended in an approximate direction at right angles to the line from the observer, the sound from that part of the path is louder or of high amplitude owing to the sound from that part of the path reaching the observer's ear at the same instant. Whenever the path leads directly away from the observer the amplitude is less, the sound is less explosive and takes the character of an extended roll or rumble.

It will be seen from this that every twist and turn and every change of direction of the spark path with respect to the observer's position gives a varying loudness and sequence of sounds. Every branch of the main discharge in like manner records its position and direction, its twistings and bendings in these sound vibrations and sequences. It would seem possible even to record on a phonograph noises from sparks invisible to the eye and map the positions of the sparks in space from records so produced. If this were done as it were stereoscopically or stereographically from two or more separated observing or recording places, the records would contain the necessary data for the reconstruction of the spark and its branches in space.

From the above considerations an attempt to determine the distance of a lightning stroke to earth by counting seconds elapsing between the flash and the first thunder and allowing five seconds to a mile approximately is seen to be futile. Should one of the cloud ramifications or branches of the great tree-like discharge extend in the cloud overhead with relation to the observer, and that part of the discharge be nearer to him than any other, he will first hear a receding rumble above him, followed, it may be, by a heavy explosion from the main or approximately vertical spark between cloud and earth and from the parts of which his distance is nearly the same. This louder explosion will then be followed generally by a prolonged rumble of diminishing loudness which is the sound coming from the ramifications which lead farther to the distant parts of the cloud. Manifestly the counting of time should be between the flash and the heavy explosive sound due to the vertical part of the flash.

Bearing in mind that over the extent of cloud the charged water particles may be said to be waiting for a chance to discharge to earth, it is not surprising that any path which has been opened or broken down by disruption of the insulating layer of air should serve for the discharge of an extended body of cloud. The heated vapor or gas in the path of the discharge is a relatively good conductor of electricity serving to connect the cloud mass to the earth below. The significance of this is understood when it is known that many lightning discharges are multiple. Instead of a single discharge they consist of a number rapidly following one another through the path or spark streak opened to them by the first discharge. This first discharge opens the way or overcomes the insulating barrier to the discharge of portions of the cloud mass, which, on account of remoteness or lower potential, could not themselves have caused the breakdown. These repeated or multiple flashes are exceedingly dangerous, both to life and property. The first discharge may reduce wood to splinters and the subsequent ones set it on fire. The time interval between the successive discharges in such a multiple flash is quite variable and may be long enough to be easily perceptible by the eye. The multiple character is easily disclosed by the image in a revolving mirror. If a strong wind be blowing at the time of such a multiple flash, the hot gas conducting the discharges may be displaced laterally in the direction of the wind with the result of spreading out the discharges into a ribbon more or less broad. Photographs of these ribbon flashes show their true character plainly; each separate discharge appearing as a streak of light parallel to the others and at varying distances apart. In part, parallel discharges of exactly the same contour are sometimes observed many feet apart. Here the hot gas of the first discharge has evidently been shifted by the wind over a considerable space before the second and subsequent discharges took place. Heavy rain seems to weaken the air and help to precipitate a discharge. From the fact that strokes of lightning are often followed by increased fall of rain within a few seconds, it is a prevalent idea that the increased downpour is caused by the discharge. In reality the reverse is the case, for just when a gush of rain has reached from the cloud down to within a hundred feet or more from the ground, by far the major part of the air layer has been so weakened electrically by the presence of the water drops, that the discharge itself anticipates the completion of the distance of fall of the rain, and is therefore a short time in advance of the time when the descending gush of rain actually reaches the ground. As the gust or gushes of rain are more or less local and sweep along with the storm cloud, they are apt to mark out the places of the most frequent lightning strokes. Shelter sought at such times under tall trees is particularly dangerous.

The amount of energy which may be concerned in a lightning discharge is neither definite nor capable of estimation. It would seem that the widest variations in energy may occur, and this would account largely for the observed differences in the severity of the effects. It must be remembered also that by far the larger part is expended in the long spark in the air and cloud. Even when much damage is done to objects struck it is only a small fraction of the total energy which is expended on them. Most of the damage to property comes indirectly from the electric discharge by its energy being instantaneously converted into heat. This heat evolves steam and expanded gases in the interior of such materials as food and causes explosion, shown in the splintering or rupture.

A curious effect, often noted when a tree is struck and shattered, is that when the splinters, sometimes of large size, are thrown bodily out to distances of many feet from the shattered tree, the splinters in their movement remain in parallel to the tree and in a vertical position. They are frequently found standing upright after a stroke and at distances ranging up to sixty or eighty feet away. This fact indicates that the projecting force is quite instantaneous and is exerted equally and at the same moment throughout the length of the splinter in a direction transverse to its length. Such splinters are sometimes ten or twelve feet in length and several inches thick. As will be seen, a person near a large tree which is so disrupted is in danger of being struck in a different way, even if he escapes being included in the path of the stroke itself. Aside from this mechanical danger it is known that to take refuge under a tall tree during a heavy thunder storm is particularly hazardous. This is so because the human body is a better conductor than the tree trunk, particularly as the trunk itself is the last part to become thoroughly wetted by the rain. The leaves and upper parts are wet and more or less conducting, while the tree trunk itself may be yet dry. In such a case the body of a person forms a good path or shunt to the dry trunk and is therefore particularly apt to be traversed by any stroke which reaches the tree.

As before indicated, damage to buildings and other such structures can in all cases be prevented by the provision of an effective shunting path to earth. A most essential feature of such a structure as the Franklin conductor is its good connection with the ground, or better its connection with what we know as a good ground. In early times it was considered that it was quite important that the tip or upper end of the conducting rod should be sharply pointed, or should bristle with sharp points, so to speak. The tips were gilded and the points made of gold or platinum to prevent rusting. The points were supposed to draw off the lightning silently from the cloud and so prevent strokes of lightning. But for millions of volts at cloud distances almost all irregular objects on the surface of the earth are practically pointed. Perhaps on this erroneous assumption of the action of points as applied here little stress was laid on the direct path to earth being chosen and on the necessity of including with it or connecting to it other good paths such as gas pipes, bell wires, and the like. There is no need of any special provision of points. A blunt end will do as well, for after all there is practically no silent drawing off of the charge from the cloud, for it is not an insulated conductor. The provision of a lightning conductor on a building undoubtedly increases its chances of being struck by lightning, but if properly arranged it also insures that the structure shall suffer no harm therefrom. Viewed from our present standpoint it is a curious historical fact that in 1777, just after the war of the American Revolution broke out, a miniature verbal war between the advocates of *blunts* and *points*, respectively, as applied to lightning conductors raged. In England party politics led many to condemn *points* as revolutionary and stick to *blunts*. The Royal Society by majority vote decided for points, but those who so voted were considered friends of the rebels in America. George III. took the side of *blunts*. Franklin, who from the first had prescribed points, wrote from France: "The King's changing his pointed conductors for blunt ones is a matter of small importance to me. For it is only since he thought himself safe from the thunders of Heaven that he dared to use his own thunder in destroying his own subjects." The king is reputed to have tried to get Sir John Pringle, then President of the Royal Society, to work for blunts, but received the reply: "Sire, I cannot reverse the laws and operations of nature." As stated above, it matters not at all which we may use. I have, indeed, seen a number of cases in which the sharp points of lightning conductors had been melted into rounded ends by lightning.

In the foregoing we have been considering the effects of such ordinary discharges of electricity as the disruptive spark, or zigzag flash. Apparently, if the testimony is reliable, there are other and more rare forms of discharge. I allude to sheet lightning, so-called globular lightning, and to bead lightning. But it may be asked, why call sheet lightning a rare form? It is, indeed, true that when a storm is so far distant that the spark discharges cannot be seen, as when it is below the horizon, or when the spark is blanketed by a mass of mist or cloud there is to be noted a diffused light or extended illumination, which, on account of distance, may not appear to be attended by thunder. This and similar effects are often called sheet lightning. From observations during a few heavy storms, however, I am led to infer the existence at rare intervals of a noiseless discharge between cloud and earth—a silent effect attended by a diffused light, and which may be the true sheet lightning. In my experience it has accompanied an unusually heavy downpour of rain, the whole atmosphere where the rain fell most heavily being apparently momentarily lighted up by a purple glow, seemingly close at hand in the space between the rain drops. The appearance has been seen in the daytime as an intense bluish or purplish momentary glow without any accompanying sound. It could scarcely have been illusory. It is hoped that other observers will carefully note any such like effect if it occurs. It is certainly a rare phenomenon.

It is quite common that any very bright flash, the details of which from its suddenness and intensity are unobservable, be alluded to as a ball of fire. Doubtless many of the reported cases of so-called ball or globular lighting may be explained as instances of this condition of things. Nevertheless, there are so many recorded instances, apparently in substantial agreement, that it is difficult to escape the conclusion that there in reality exists this rare form of electric effect, globular lightning.

We cannot properly discredit observations of phenomena which are so rare that our own chance for confirmation of them may never come. We must, in such cases, carefully scrutinize the testimony, examine the credibility of witnesses and their chances of being mistaken. It is certainly impossible at present to frame any adequate hypothesis to account for this curious and obscure electric appearance. The witnesses agree that it is an accompaniment of thunder storms and that it resembles a ball of fire floating in the air or moving along a surface, such as the ground. It is not described as very bright or dazzling, and the size of the ball itself may be from an inch or two to a foot or more in diameter. Observers agree that it can persist for some time and that its slow movement allows it to be readily kept under observation while it lasts. When it disappears there is usually an explosion and a single explosive report like that of gun fire. Sometimes it is said to disappear silently. Usually the damage done by its explosion is only slight. This summary of characteristics is common to all accounts. Some accounts are even more detailed, mentioning that the fiery ball seemed to be agitated or with its surface in active motion. I have found two

instances occurring many years apart and in widely different localities in which it is described as having a reddish nucleus, in diameter some considerable fraction of the whole. The outer fiery mass has been described as yellowish in color. In some instances it has been seen to fall out of a cloud. It is described as entering buildings and moving about therein. Personally I was for a long period in doubt as to the reality of this strange appearance, deeming it the result of some illusion, or a fanciful myth. But on hearing descriptions by eye witnesses known to me as persons not given to romancing, and finding their accounts to correspond closely with the best detailed descriptions in publications, my doubts have disappeared.

In one instance, while observing the lightning during a heavy thunderstorm, a companion, whose eyes were turned in a direction nearly opposite to my own, suddenly called to me that a ball had just dropped out of the cloud some distance away. The view of the ground was obstructed by buildings and I unfortunately just missed it. The noise of its explosion was, however, heard in the direction indicated by my fellow observer, as a single report like the firing of a gun. At the time I closely questioned him as to details of the appearance. Our ignorance of its possible nature is complete. No rational hypothesis exists to explain it. Science has in the past unraveled many obscure phenomena. The difficulty here is that it is too accidental and rare for consistent study, and we have not as yet any laboratory phenomena which resemble it closely.

Sometimes photographs taken during thunder-storms have been found to carry curiously contorted streaks in some degree resembling lightning flashes. Generally they have been found on plates upon which undoubted lightning discharges have been recorded. In some instances which have come to my notice the streaks have had the appearance of a string of dots or beads and have been taken to represent a very rare form of lightning known as bead lightning. A number of such photographs have been submitted to me for opinion as to the nature of the curious streaks. In all cases they are explained as due to the camera having been moved without capping the lens, permitting images of lights, such as arc lights, or spots of reflected light from wet or polished surfaces to traverse the plate in an irregular course. They are then only records of the inadvertence of the lightning photographer. In one instance the effect was so curious that it was several years before the true explanation was found. In that case there were two wavy contorted streaks of perfectly parallel and of similar outline, but unequal in intensity, rising each from a rail of a single track railway, and apparently terminating in the air fifteen or twenty feet above the tracks. They were finally traced to a moving camera, and a reflection from the wet and polished rail surfaces of the light of an arc lamp located outside the field of view. It required a visit to the place itself to enable this conclusion to be reached. The particular beaded streaks or lines of dots were traced to the fact that the arc lamps causing them were operated by alternating currents which naturally give light interrupted at the zero of current; one hundred and twenty times per second being the usual rate. All this emphasizes the need of care and wholesome scrutiny or even skepticism before reaching a conclusion in such cases.

Is bead lightning, which has at times been described as observed visually, a reality? If it is it appears to be even rarer than the globular variety. Perhaps it is a string of globules; a variety of globular lightning. But we cannot make assumptions. As in the case of globular lightning there is some testimony, which cannot be wholly disregarded, tending to show that a form of discharge resembling a string of beads can actually exist. An account of an instance was given me within one hour after the occurrence itself. The witness was known to me as perfectly reliable. The appearance was described as a festoon of finely colored oval beads hung as it were from one part of cloud to another, and as persisting for some seconds while gradually fading away. The opposite ends of each bead were said to be different in color. It was seen during an afternoon thunder-storm and spoken of as very beautiful, and altogether different from the usual zigzag flash.

If I have dwelt upon these exceptional appearances at some length it is because they seem to show that in electricity there is much yet to learn and abundant opportunity for future investigation. It is certainly literally true that, in the language of Shakespeare, "There are more things in Heaven and earth, Horatio, than are dreamt of in your philosophy." Such work belongs to the science of physics, now recognized as fundamental in all study of nature's processes. In electrical engineering, which is in reality an art based upon applied physics, the subject of lightning protection has always been one of considerable if not vital importance. Just as a lightning discharge from a cloud clear up a path for other discharges to follow, so in electric undertakings it opens up paths for the escape of the electricity we are sending out to do the work intended, such as for lighting, power or other use. In the past, disablement of machinery in electric stations has not been rare. The recent growth of long-distance transmission involving hundreds of miles of wire carried on poles across country, over hill and through valleys, has set new problems of protection, and called for renewed activity in providing means for rendering the lines and apparatus immune to the baneful effects of electric storms. Judging the future by the past, we may conclude that, whatever difficulties of the kind arise, in the great future extensions of such engineering work, science and invention will provide resources ample for the needs, and the rapid advance will be continued.

THE EXCAVATIONS OF ARLESIA.

ONE of the most interesting problems of archaeology has been finally solved by the recent excavations accomplished at Alise-Sante-Reine laying bare the site of Arlesia, that city of ancient Gaul where Vercingetorix headed 80,000 of his countrymen in a last gallant though futile attempt to stem the advance of the victorious legions of Julius Caesar.

In 1905 the Society of Historical and Natural Science of Semur undertook the task of uncovering the riches of the plateau of Mount Anxois, and on May 1st, 1909, the plan of the ancient city was finally disclosed at Alise, thus nullifying the rival claims of Alaise (Doubs).

Caesar's only geographical reference to the location of the place is contained in the words: *Alesia, oppidum des Mandubicus.* But a document exists which confirms the site. This is a votive inscription in the Celtic tongue found in 1839 on the plain of Alise, reading thus: Martialis Dannotah Ievra Wscueti sosin celicnon etic gobedbi dugeontico Wanetin in Aliisia. This translated reads: Martialis, son of Dannotalos, made for Weuetis this monument and erects it for Weuetis in Alise. Dr. Vercontre shows by the text of the grammarian Consentius that in the Gaelic language the letter *i* is pronounced not as in Latin, but with a sound intermediate between *i* and *e*. It follows that they pronounced as Alesia the written word Aliisia, which Caesar merely spelled as pronounced.

Napoleon III, who wrote a history of Caesar, attempted to settle the question by excavating the remains of the admirable lines of contrevallation and circumvallation, of more than 16 kilometers in extent, drawn by the Roman legions around Alesia, but succeeded only in uncovering numerous tombs recognized to belong to a period many centuries prior to that of Caesar.

More recently the idea was conceived of digging a shaft perpendicular to the assumed lines of investment. The soil of the plateau consists of a soft dark vegetable mold overlying a subsoil hard, white, compact and flinty. In the latter distinct traces were discovered of 1.5 meters to 2.5 meters in diameter, whose outlines were clearly shown in geometrical fashion on the walls of the shaft. These lines concurred in design and dimensions with those described in the Commentaries. Within these trenches were found bucklers and objects of equipment of Roman and of Gallic origin and bearing in their form and structure the character of arms of Caesar's epoch. In one was found a handsome case of silver, ornamented with a garland of leaves and berries in relief.

It seems certain that Alesia was destroyed at least three times. Attentive study of the remains shows three different epochs in the history of a Gallo-Latin city besides the original Gallic period.

The first is characterized by walls whose facings are very regular and composed of the best material. The construction is very solid and careful and the joints have usually been fired.

The second epoch (at the end of the first century A. D.) shows material of less value arranged with less art, while at many points walls of the first period have served as under-pinning for those of the second.

Finally, much later, following a new destruction (second or third century A. D.), the city was rebuilt, but with walls narrow and inferior, showing the poverty of the place, which was constantly ravaged by the barbarians till its final overthrow, which the study of its money and pottery shows to have occurred about the fifth century after Christ. For a thousand years or more the very existence of the ancient city was unsuspected, the medieval city clinging to the flank of the hill, where a modern village has replaced it.

It must be noted that among the Roman ruins were found the remains of Gallic huts, usually slightly sunk in the soil and built of baked clay. The fragments found show the precise method of construction.

Wattles were built of peeled branches in the exact outline of the proposed edifice. On each side of this structure was applied a thickness of several centimeters of clay, and the whole was then baked by fire applied both within and without. Thus the wood was carbonized and the earth transformed into solid baked clay.

Wells, cisterns, and aqueducts exist in considerable numbers on the plateau, and many of these, excavated to the rock yielded innumerable objects preserved intact.

Among these may be mentioned bronze caldrons, a jug with its tray, a perfume vase, a wooden bucket bound with iron and bearing a meter's length of chain, and finally a wooden musical instrument.

This last object is the most precious of all, for it is nothing less than a genuine pipe of Pan, and is absolutely unique, no other example having descended to us from antiquity.

Beautiful bas-reliefs and statuettes have also been found. It was first the Capitoline Triad—Jupiter between Minerva and Juno, which marked the importance of the monument with three apses where it was found; then one of Castor and Pollux, one of the Heavenly Twins being in good condition, while of the other only the head and some fragments of the horse were found.

Of special importance is a mutilated statue of a Gallic chieftain, showing the apparel, the tunic, and a sword belt to which a short sword was attached by thongs.

Other articles are an Amazon, a Jupiter, a divinity with doves which recalls certain Germanic Gods, a life-size head of a woman—goddess or empress—and above all three heads with closed eyes of negroid type which recall, perhaps, the cults of Hercules, said by the ancients to have fought negroes and to be the founder of Alesia.

Then, too, a curious Ephona, goddess of horses and stables was brought to light, as also a small plaque of bronze of the same divinity minus a head.

Of the numerous pieces of pottery some are beautiful, and one, bearing an image of the god Mithra, really remarkable.

Perhaps the most interesting of the Gallo-Romanic ruins is the great theater with a facade of over 24 meters placed against the side of a hill. Behind is the superstructure of a temple. Beside the walls is the base of the altar where the priest stood; outside, in a space limited by a portico, were the worshipers.

Further to the east was the great monument with three apses which contained the temple and made part of the same architectural *ensemble*. This seems to indicate a pagan basilica adapted at the dawn of the middle ages to the uses of the Christian faith. At the north of this monument is found a vast quadrangular structure whose facade contains a double row of columns placed at different levels. It was near this that there were found in a house which must have been used as a workshop, troughs and fragments of mills which indicate the nature of the industries of Alesia.

In the sixth and latest excavation a vase was found which is a most beautiful example of these arts.

To the east of the monument of three apses is the forum, bounded at the north and south by columns the bases of whose pillars are still visible. Ruins of many houses are found in some of which the hearths are still filled with ashes.

According to Pliny, Alesia was the seat of a famous industry, plating and silvering, especially the making of arms and equipage of silver. Such an *industrie de luxe*, of course, shows a high degree of civilization.

Reinach sees in this a correspondence to the Celtic art of enameling which existed at Bibrach. The passage in Pliny relating to the metallurgic crafts of Alesia has been corroborated by recent finds, particularly a mirror of bronze lined with lead, and some of the utensils of the bronze-makers consisting of troughs and crucibles of refractory earth in which the bronze was melted and fragments of mills of baked clay into which the metal was poured to be cooled, according to a process still in use at the present day.

A museum will shortly be opened at Alise for the display of these relics.—Abstracted from Le Monde Illustré for the SCIENTIFIC AMERICAN SUPPLEMENT.

THE PROCESSES IN COTTON SPINNING.*

A REVIEW OF AN INTERESTING INDUSTRY.

BY LEON A. HACKETT, S.B., '04.

The cotton-manufacturing industry of this country has an annual production of nearly half a billion dollars' value, 33 per cent of which originates in the State of Massachusetts alone. The industry, while expanding as a whole to meet future requirements, has nevertheless fallen off in Massachusetts during recent years in its percentage growth, when compared with other sections of the country, and indeed with the prospect now that the center of the industry will eventually move to the South.

The increase of fixed capital, in fact, during the past eight years, for Massachusetts has been but about 20 per cent, while for the South, in a corresponding period, the increase has been well over 140 per cent.† This shows that the manufacturing output for home and export trade is far from being abreast with the demand for goods, and further indicates that the deficiency in production of this principal staple manufacture of the State is to be supplied from another locality.

With a view to giving some general idea of the manufacture of cotton, an industry in which Massachusetts has long been foremost, the following is presented, being, however, only an outline of the operations in that branch of cotton manufacture concerned in the production of cotton yarn from raw cotton. To the average reader, unacquainted with the manufacture of this particular staple, an explanation of cotton-spinning as a whole is of first importance, one that does not enter elaborately into details, but gives a notion of what is accomplished in the factory, and what machines and materials are used, and what principles are involved in the various stages of progress. In such an explanation as this there will necessarily be introduced some few technical terms peculiar to the particular process described, without which the explanation would be less intelligible.

In the spinning of cotton yarn there are five processes, or really five types of machines, through which the cotton must pass in its manufacture into yarn. These processes are the picking, the carding, the drawing, the process using the machine called a roving-frame, and the final process of spinning proper.

PICKING.

The picking process, which is the first to handle the cotton, has two purposes—first to clean the cotton of its broken leaf, sand, and very short fibers, and then to prepare the cotton into a suitable shape to be treated in the next process of carding. Four machines are used successively to do this, which are shown in Fig. 1, in the order of their working, as feeder, breaker picker, intermediate picker, and finisher picker.

Cotton, as received at the mill, comes in the form of bales approximating 500 pounds in weight, compressed to about 16 pounds per cubic foot. From this previous treatment the fibers have become pretty well matted together, and when they arrive at the mill

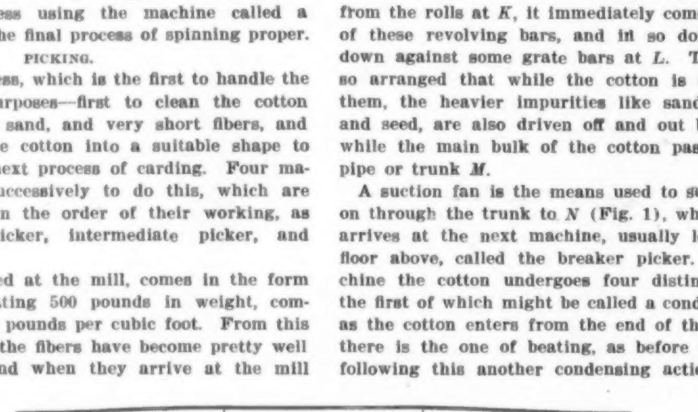


Fig. 1.

and are opened up, they do not return to their natural fluffy state without considerable mechanical handling.

The feeder (Fig. 2), which is the first to operate after the sacking and bale-ties have been removed, is designed to break up the cotton into comparatively small pieces from the large matted ones that are thrown into the machine hopper by hand from the mixing pile. The large pieces get tossed about in the feeder and come finally into contact with the spiked traveling lattice $A\,B$ moving up the side of the hopper-box, to which they are carried forward by the other lattice $C\,D$ moving along the bottom. As the cotton is carried forward to the spikes, some pieces are caught there of larger size than permit their passing by at the space E, and in consequence are knocked back by the revolving spiked roll F. Later these pieces again repeat the climbing-up operation, until the stock has been so disintegrated that it is all enabled to pass on. It will be noticed that this knocking back of the large pieces of cotton during the action of the feeder is virtually a regulating action to the supply. The cotton next enters what is called the beater-chamber at G.

This is a cylindrical chamber containing the beater H, which is the vital part of the machine. In construction, the beater is simply three parallel bars fixed, and so bolted securely to arms about a center that they may be revolved at a high speed of 1,500 revolutions per minute. As the cotton is fed out from the rolls at K, it immediately comes in the path of these revolving bars, and in so doing is dashed down against some grate bars at L. These bars are so arranged that while the cotton is opened up by them, the heavier impurities like sand, broken leaf and seed, are also driven off and out between them, while the main bulk of the cotton passes on into a pipe or trunk M.

A suction fan is the means used to send the cotton on through the trunk to N (Fig. 1), where the cotton arrives at the next machine, usually located on the floor above, called the breaker picker. In this machine the cotton undergoes four distinct operations, the first of which might be called a condensing action, as the cotton enters from the end of the trunk; then there is the one of beating, as before in the feeder, following this another condensing action, and lastly the formation of a lap. The condensing action will be more clearly shown by reference to Fig. 2, the intermediate picker machine.

Two horizontal screened cylinders called cages (A and B) here revolve in opposite directions about twice a minute. The length of these cages is 40 inches, and their ends are so mounted in the sides of the machine that by means of an air-duct not indicated, leading from the ends of the cylinders to a suction fan, a pressure slightly below atmospheric is produced, so that the cotton as it enters the chamber C is at once attracted here to cover up the slowly moving screen surfaces. At the point D, as the cages continue to turn, the seal of the air chamber is passed, and the cotton peels off in the shape of one thick ribbon from both screens. In the breaker picker (Fig. 1) this condensing action is the same.

Now we will return to the point where the cotton from the trunk M passes on to N. Here it is condensed momentarily into a short ribbon (P), then an instant or so later it enters the chamber Q to be broken up by the beater, and finally is condensed

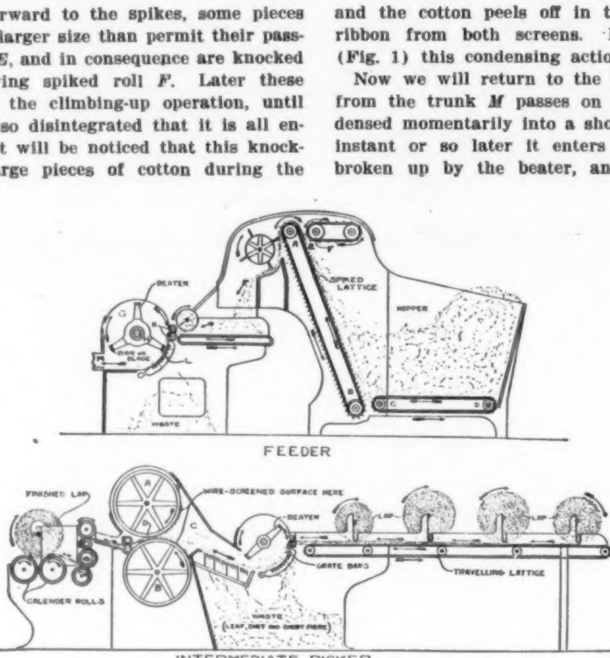


Fig. 2.

again at the cages R, when it peels off into a ribbon at S. It passes now in and out around some heavy rolls and is wound up in a roll at T. In this form of a roll, the cotton is called a lap, being a huge wound-up ribbon of cotton 40 inches wide, 50 inches or more in length, and of weight from 40 to 50 pounds.

As a result of these two operations in the feeder and the breaker picker, the cotton is somewhat the cleaner and is in a form convenient for handling, namely, a lap. The laps which are formed in the breaker picker are next taken by hand and placed on the traveling lattice at the back of the intermediate picker. Four of these laps unwind together, pass on to the beater for the extraction of more dirt, and then are returned into lap form as before at the front of the machine.

The above constitutes the complete series of operations of the picking process, but for further cleanliness and for uniformity in the lap the intermediate picker and the next machine to follow, called the finisher picker, are used.

CARDING.

The treatment of the cotton in the carding process is one tending toward the individualizing of the fibers; that is, a process where the cotton is so closely dealt with that the fibers may each be said to have been separated once during contact with the operative part of the card. The process by which the fibers undergo this minute handling is of the nature of a brushing or combing action, where all the fibers are subject alike to the same treatment with combs. This brushing action, too, instead of being repeated over and over again, is continuous, and the fibers are held fast at one end during the treatment only through embedding in the bristles or teeth of one brush, while another performs the combing or individualizing. The degree to which the fibers are actually individualized into what might be called parallel order, such as will be needed later for the formation of the thread, is probably very small, but they are sufficiently loosened up here to adapt themselves readily to this order in the next operation.

The combing action, as used in the card, is indicated in Fig. 3, where the bottom comb or carding surface A of the cylinder acts as a carrier of the fibers bodily forward, to meet continually new clean bristles, or teeth, of the top comb or flats, and also to hold the fibers sufficiently embedded in the teeth so as not to slip by easily from one tooth to another during the operation here. When the cotton fibers are placed between the two brushes or carding surfaces of the machine of this process, the straightening and isolating action is at first a gradual one, as the brushes move by one another, but after contact with the upper brush has continued for a moment, there comes a distinct betterment in the order of the fibers. It will be seen from the figure that the spaces between many of the teeth of the upper surface are filled, or partially filled, and the representation here is that of the ex-

* Harvard Engineering Journal.

† Census Report, Bulletin 97, p. 12. This does not include 1909.

tremely short fibers, which have been caught in these upper carding points of the flats, as they are called. These fibers constitute undesirable stock, which should be removed from the cotton, as they would work poorly in the spinning operation later. The reason why these short fibers in the flats are detrimental to the finished yarn is that they are the immature cotton fibers, which are always present to a more or less degree in all grades of cotton, and as such do not possess the convolutions, or twists, in the individual fibers that the ripe ones do. These convolutions, or twists, in the fibers serve the purpose of interlocking with each other, and by so doing give the strand some appreciable strength (see Fig. 9).

An arrangement in the carding-engine provides for the removal of the short fibers through cleaning the flats as they turn, in course of their slow rotation, out of contact with the cylinder at about the point *B*.

A general description of the card may now be given, and the passage of the cotton followed through the machine at the same time. A card, as used in cotton manufacture, is a machine that has many of its active contact points concealed from view, so that when observed casually its means of operation are not at all apparent. In Fig. 3 a sectional view is given, and also enlarged sections of operative parts connected therewith.

The form in which the cotton is received in this process has already been stated as that of a broad rolled-up ribbon of cotton, or a lap, and now as it leaves the card it takes the form of a strand an inch or more in diameter. From the lap that is fed into the card, each yard is turned into from 100 to 120 yards of cotton strand of soft rope form, this number of yards with corresponding diameter being governed largely by whether the ultimate yarn is to be a coarse or a fine one.

The lap is placed at the back of the card and unrolls

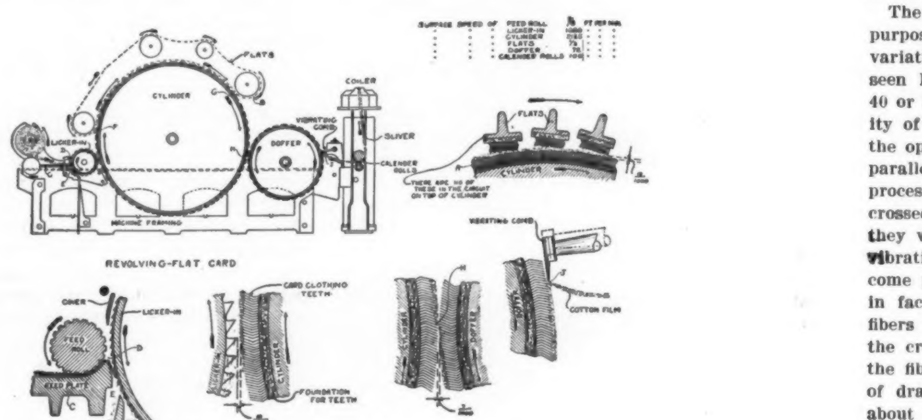


FIG. 3.

along the feed-plate *C*, until the end of the lap reaches the point *D*. At this point the cotton is snatched away in small tufts by the saw-toothed surface of a cylinder, revolving very quickly, which is called a licker-in. These little tufts of cotton which the saw-teeth pick off are dashed down against some grate-bars, or knives, at *E*, and at the same time any dirt still retained in the lap is driven out between the bars. The licker-in saw-teeth also throw the fluffy cotton down farther upon the cylinder, where it at once adheres, through the action of induced air-currents. At the cylinder the operation of the card may be said fairly to commence, the licker-in being essentially a feeding and opening-up arrangement preparatory to the carding of the cotton proper. This main cylinder and operating part is usually about 50 inches in diameter and 40 inches wide, and is made of cast iron and provided with an axle for its rotation. It is also covered with a so-called card-clothing, the action of which is the direct means for combing and separating the fibers. In appearance the card-clothing is somewhat like a music-box cylinder, only the points on the latter are spaced far more coarsely than those of card-clothing on the card-cylinder. An enlarged section, given in Fig. 3, shows plainly the clothing teeth, as attached to the cylinder, the flats, and the doffer, and also the relative positions of these teeth when the cylinder is working against the flats or the doffer. The number of points in the card-clothing runs about 65,000 per square foot, and on the basis of calculated surface-speeds, there are from 10 to 15 points presented for every fiber that passes through the machine, and this, in view of the purpose of the card to individualize the fibers, would seem to be a ratio sufficient to have some effectiveness.

Starting now at the point where the cotton is caught on the cylinder, we notice that it is carried immediately in the opposite direction a short distance before it comes under the action of a number of flats that begin combing at *F*. Then from *F*, the cotton is carried forward while embedded in the cylinder-teeth from one flat to another until, at *G*, the action of the flats ends. Notice will have been taken of the close setting of the flats to the cylinder from Fig. 3, so close that any fibers placed between flats and cylinder must needs be torn apart or individualized by the action of so many teeth. After being carried by all the flats by the cylinder, the cotton continues a short distance farther to *H*, and then another smaller cylinder comes into operation, acting as a sort of "stock remover" to the large cylinder.

This smaller cylinder, which is placed almost up to tangency with the larger one, is called the doffer, and its only purpose here is to transfer the cotton from the main cylinder to this smaller one. The principle by which this transfer is accomplished is a trifle puzzling, as both the actions of surface-speeds and combings are involved. The large cylinder turns at 160 revolutions per minute, or has a surface-speed of about 2,100 feet per minute; the doffer, 27 inches in diameter, moves about 10 to 12 turns a minute, or with a surface-speed of about 72 feet. This means that 29 inches of surface of the cylinder, all laden down with loosened fibers, pass by for every single inch of surface of the doffer, that moves away from the point of tangency. The inclination of the doffer cylinder-teeth being favorable to receive the fibers from the cylinder, and the distance between the two cylinders only 7-1000 of an inch, the transfer is readily effected so that the doffer practically backs off with the fibers that are thrown upon it, and moves away with them to the point *J*.

Here a vibrating comb acts to clear or knock the fibers off from the doffer in quick little raps, and they peel off in the shape of a broad transparent film of fibers. The film is drawn out a short length, when it is contracted into a funnel-shaped piece which brings the cotton to the form of a strand. Then, in the form of a strand, the cotton passes through some calender rolls to be slightly compressed, and into a coiler, where a means is provided to pack the strand away, in the shape of circles or coils in a can, for the temporary disposition of the fibers until withdrawn again later in the course of manufacture.

DRAWING.

In this process the cotton is received in the form of so-called sliver from the card, and, after having been operated upon, it leaves the process in much the same form in which it was received. Indeed, it does not appear from a casual inspection to have been changed at all by the action of drawing. If, however, several individual 1-yard lengths of the sliver were weighed, their respective weights might be say 55, 51, 59 and 51 grains each per yard, an average of 54, with a maximum variation of 5 grains from the average. Then at the end of the process, any other four yards, measured off at random, would likely have weights 40, 41, 42½, and 40½, an average of 41, with a variation of 1½ grains from the average.

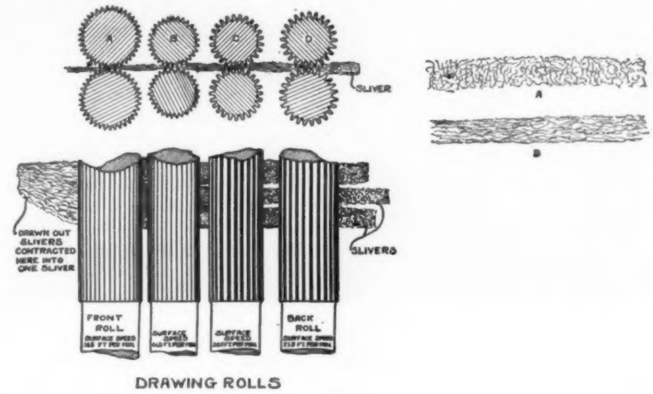


FIG. 4.

The result of the drawing, and one of its main purposes here, has been to reduce the extent of the variations in weight, it being immaterial, as will be seen later, whether the full weight of the sliver is 40 or 50 grains in itself. Beyond this added uniformity of the strand, there is another benefit derived in the operation of drawing, which might be termed the parallelization of the fibers. At the beginning of the process, the fibers of the strand from the card were crossed in every direction along its length, just as they were beaten off from the doffer cylinder by the vibrating comb. Now in drawing, these fibers become placed in very close alignment to one another, in fact an extreme case of the arrangement of the fibers would be represented in Fig. 4, where *A* shows the crossed positions of the fibers, *B* the relation of the fibers after having passed through this operation of drawing. Three machines are required to bring about the required uniformity of the strand, and to parallelize the fibers, all of which are of the same type, the operations being merely repetitions of one another in different machines.

In Fig. 5 is shown an end sectional view of a draw-frame; also, in Fig. 4 on a larger scale, the four pairs of fluted rolls, *A*, *B*, *C*, *D*. These latter are what do the drawing. The upper rolls move from contact with the under ones, while the latter are positively driven by gearing on their ends.

Six slivers from the card are passed in at *A*, and through accelerated surface-speeds of the rolls are delivered at *D*, in one combined sliver of about the same size as any one of the six to enter. There has, therefore, been a drawing action of six, to accomplish this reduction in size, and by so doing, thick variations in one strand will be found to have frequently come opposite thin variations of the other, while the resulting strand or sliver becomes more nearly an average of all.

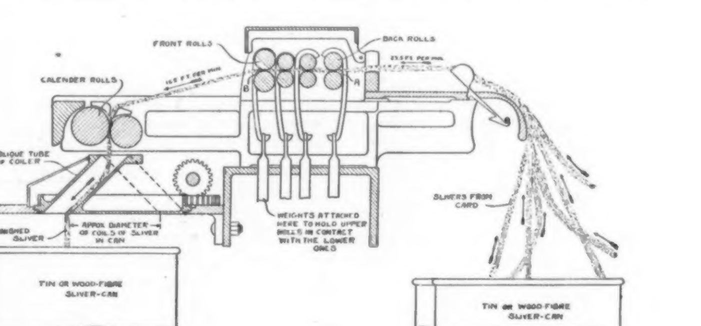


FIG. 5.

At the front of the draw-frame an arrangement called a coiler is used, the same as that employed in connection with the card, and by means of it the sliver is packed away in a tin can in the form of circles or coils, in such a manner that entangling is infrequent when it is withdrawn again for later use.

A delivery is the unit of capacity of the drawing-

frame, and the term refers to the number of finished drawn slivers delivered from the front drawing-rolls in any complete drawing-frame machine. That is, when six cans of sliver from the carding process are clustered together at the back of the draw-frame, and their strands are all united and drawn into one at the front of the draw-frame, then this is called a delivery. Four, five, or even six finished drawn slivers are the usual deliveries constructed for draw-frame machines, depending upon the space or special requirements of the room, where, in these cases, the cans at the back of the machines would be 24, 30, and 36 respectively in number.

(To be continued.)

Correspondence.

ESPERANTO VS. IDO.

To the Editor of the Scientific American Supplement:

In the Scientific American Supplement for May 28th I note an article headed "Ilo, a Third Universal Language," with a sub-head "An Improvement on Esperanto," presumably copied from Umschau, as one paragraph starts off, "A writer in Umschau."

No doubt you print the article in good faith, as a matter of news, likely to interest many of your readers, but there are so many gross misstatements therein, and it is so evident that you, ignorant of the real facts, have been imposed upon by those who are doing everything possible to wreck the international language "Esperanto," that I cannot permit the incident to pass without strong protest. I am one of those who have given the question of an international language much study, have thoroughly mastered Esperanto, made a close examination of the extravagant claims put forth for this alleged "improvement," and know whereof I speak. Nothing would be easier than to disprove all of the pretensions made in your article for "Ilo," were you willing to accord me sufficient space; but as you confine yourself to some bald statements, I shall merely call your attention to those which are false, in the hope that you will be sufficiently fair to present to your readers the other side.

You say, "The Esperanto language thus cannot as yet be considered the solution of the problem. The intelligent leaders of the movement are fully aware of this, particularly M. de Beaufront, as a champion of the reform, while the inventor, Dr. Zamenhof himself, has approved in very material points." Esperanto has been used for almost every conceivable purpose for nearly twenty-five years, has been found most excellently adapted to its purpose, and has more than *400 times as many adepts and supporters as all other proposed languages put together.* Dr. Zamenhof has NOT approved of any change, but on the contrary has never failed to raise his voice against such action, pointing out the grave danger of any interference with the fundamentals of the language, especially from self-appointed committees and individuals who for one reason or another pose as "saviors." In this position he has the unanimous and enthusiastic support of the "Language Committee" with its inner "Academy," to which are referred all questions affecting Esperanto, for settlement.

It is true that Esperanto has six characters in its alphabet which require special type, but French has several, also German, Spanish, and many other widely used languages, and there is a most excellent reason for their introduction. Furthermore, these special characters may be readily and cheaply purchased from any type-founder or linotype dealer, and in fact are found already in many leading printing establishments.

You say, "Under the circumstances no progress can be expected of Esperanto, . . . the paucity of roots is so great." Esperanto is a living language, in practical use by many hundreds of thousands of people all over the world, for pleasure, social intercourse, and business, also largely for the transaction of the affairs of various scientific, political, religious, and other societies and associations of an international character, and is growing and evolving precisely as any other language grows and evolves. Its original vocabulary was simple, as that of any international language with the slightest hope of success must necessarily be, but it was entirely sufficient for all ordinary needs, and to satisfy the requirements of scientists and specialists in various matters many thousands of words have been added since, a dictionary of the same now being in preparation which will contain upward of 100,000.

As regards "Ilo," permit me to say that it is merely a plagiarism of Esperanto, an imitation with many radical changes, none of which can be considered, in the light of intelligent, unprejudiced comparison, as an improvement. On the contrary, Ilo is far more complex, has re-introduced many of the alphabetical absurdities and language faults found in French and English, and, so far from "not being exposed to the danger of being supplanted by the creation of a still better and materially different language," suffice it to say that up to date no fewer than six former supporters of "Ido," or "Ilo," as it is variously called, have become dissatisfied with the language and published books of new systems, each one alleged to be better than any of the others.

Esperantists, even Dr. Zamenhof himself, make no claim that Esperanto is perfect or not susceptible of improvement. On the contrary, it is constantly being improved and made more efficient, but in the only rational and feasible manner, as provided for in the "Fundamento." There are defects in Esperanto, just as there are in English and other languages, or in anything else built by human hands or brain. But we are fully cognizant of this; that Esperanto has been proven to be most excellent for its purpose by the only logical test—that of continued USE; that Esperanto is simple, easy of acquisition, has no difficulties which anyone cannot master with reasonable effort; that any search for a "perfect" language is futile, as no two persons can agree as to what constitutes perfection; that what is wanted is *agreement between all nations upon SOME ONE LANGUAGE,* whether that language be Esperanto, English, French, Chinese, or Choctaw; that to permit these pompous gentlemen of the self-appointed, so-called "delegation" to change the language to suit themselves would at once render valueless the vast literature of our language, discourage and disgust the great army of supporters and adepts, open the door to any other "delegation" next year or ten years hence, and bring down in ruin the great edifice which we have labored so long and strenuously to erect—without any compensating advantages whatever.

To make a success of this movement—one of the greatest and most important in the history of mankind—the sole method is to *sink all personal preferences, unite upon some one established and proven language,* and say to the world, "Learn this tongue, safe in the assurance that you will not have to discard it and commence all over again six months hence."

Charles E. Randall,
President Seattle Esperanto Society.
Seattle, Wash.

[This letter is one of many which we have received from subscribers, all of them ardent Esperantists, who fail to realize the purpose of the creators of Ilo. That purpose is admirably outlined in a recently published book entitled "International Language and Science," which consists of a series of papers by Prof. L. Couturat, O. Jespersen, R. Lorenz, W. Ostwald, L. Pfaundler, and F. G. Donnan. Those Esperantists who may take issue with the statements made in our article will do well to read this book.

The question of a so-called world language is so much in the hands of enthusiasts that it is difficult to form an unbiased opinion concerning it. The linguistic aspect of the question has been confused with so many side issues, that the formation of a commission consisting of literary and scientific men of eminent reputation to consider it was necessary. Such an international commission exists in the *Delegation pour l'adoption d'une langue auxiliaire internationale.* After profound researches extending over seven years, the delegation has shown that a sound idea lies at the root of the various movements for a universal language, but also that neither Volapük nor Esperanto has succeeded in solving the problem. As, however, Esperanto was found to contain many excellent features, the commission finally resolved to work out, on purely scientific principles, an international auxiliary language on the basis of Esperanto. It is this language which our Esperantist friends repudiate, without realizing, in our opinion, the purport of its creators.

It is far from our intention to attack Esperanto. Dr. Zamenhof performed a wonderful work when he created Esperanto at a time when the question of an international language had ceased to interest humanity, and succeeded in producing a tongue which, despite its defects, is decidedly superior to all previous attempts, and which has proven itself a serviceable though not ideal means of international communication.

It is unfortunate that many of our subscribers regard the Marquis de Beaufront as a renegade from the Esperanto movement. It should not be forgotten that it was through the Marquis's efforts that Esperanto became widely known in France. His disinterestedness is shown by the fact that he gave up his own invention, "Adjuvanto," as soon as he came to know about Esperanto. If he has allied himself with the delegation, it must surely be for sound philological reasons.

The distinguished chemist, Wilhelm Ostwald, has given an account of the work of the delegation. The commission consists of representatives of the English, German, Italian, Scandinavian, and Slavonic languages. Famous philologists, scientists, and philosophers have given valuable assistance. Concerning the work done, Ostwald writes: "Although the labors were very fatiguing, they proved all the more effective for the progressive elucidation of the problem in hand. From the very multiplicity of the attempts at a solution, and their discussion, there arose in the minds of the workers, in a manner never to be forgotten,a clear conception of the main conditions required for a successful solution of the problem and a recognition of the errors which a disregard of one or other of these systems had produced in the existing system." The delegation decided that none of the existing systems fully satisfied the conditions necessary for an international auxiliary language, but that the widely-known Esperanto would serve as a basis for the working out of such a language, although certain changes were necessary.

A standing committee was elected, including Ostwald, Couturat, De Beaufront, and Jespersen, which was intrusted with the task of determining the new forms of the international auxiliary language on the basis of the principles laid down in the sittings mentioned above. The changes carried out by the committee of the delegation are embodied in the form of new grammars and dictionaries. The delegation succeeded not only in recognizing, but also in correcting in a competent manner the errors of Esperanto, with the result that we are to-day in possession of a language which in respect of facility, lucidity, variety, and elegance of expression, represents the pinnacle of international speech. The new language has been called "Ido" (that is, *a descendant*) because it sprang from Esperanto.

The new vocabulary contains in round numbers 5,400 stems, and in spite of the Romance character which the international language necessarily possesses, forty per cent of these are common to German, English, French, Italian, Russian, and many other languages. Moreover, there are naturally numerous other stems which occur simultaneously in four or five of the great languages. This simply proves that it is only necessary to select judiciously the words common to the living languages, that is to say, by an artificial process, in order to construct an international language.

Esperanto has suffered because it has fallen into the hands of scientifically untrained persons, and sometimes into the hands of fanatics. Added to this was the desire to soar to the summits of literature instead of confining the language to the practical affairs of life, and the truly childish confidence which has led to the spoiling of the classics of different nations by translating them into language intended for other purposes. The delegation has labored hard to free the question from all extraneous considerations. Naturally, the delegation marks, therefore, without doubt, the beginning of a rational period in the history of the movement for an international language. It has taken the standpoint that the solution of the problem is purely scientific and technical.

Perhaps the man who has been most hotly attacked in this effort of the delegation to improve Esperanto is Prof. Jespersen. He has, however, been well able to defend himself. He points out that Dr. Zamenhof was not quite able to free himself from the influence of his Slavonic mother tongue when he created Esperanto. Before he arrived at the conviction that the material for the vocabulary must be obtained from the Romance and Germanic languages, and that the already existing stock of international words must be used, he had "simply invented" his words, that is to say, chosen them quite arbitrarily, but with as much regard to system and brevity as possible. Although he himself noticed that such words are difficult to learn and still more difficult to remember, he has unfortunately retained in the finished language a whole series of such formations, which appear in words of such frequent occurrence as "who," "how," "where," "never," "everywhere," etc. Dr. Zamenhof has shown a fondness for sibilants and diphthongs, which is especially evident in the invented words (e. g., *chi,* here; *chiu,* each; *ech,* even; *ghi,* that; *ghis,* until). Prof. Jespersen also points out that Russian usage has inspired such word formations as *esparoli* and *senkulpigi,* instead of the international *pronuncar* and *exkuzar.*

It will probably be conceded by Esperantists that an auxiliary language must be based on the principle of maximum internationality. Logical precision of expression is another condition. Esperanto has a vocabulary very far from being constructed according to the principle of maximum internationality or logical precision. On the other hand, the Esperantists are supposed to make up for this defect by the famous principle of *vortfarado,* that is, word manufacture, with the result that their language falls into the error of creating idioms. For example, in Esperanto the beginning of the sentence, "A rotary transformer might be called a motor generator, but the latter name is usually applied to machines with independent armatures," is translated in the following way: "*Turnighanalispecigilon oni povas nomi motorproduktanto,*" which literally translated reads, "*A self-turning otherwise-making instrument can be called a motor producer.*"

Esperanto lacks a scientific method of word formation. Hundreds of times the puzzled reader of an Esperanto text is in doubt about the sense of an

adjective, even such common expressions as "stone" and "made of stone" being rendered in Esperanto by the same word (*shtona*).

The language of the delegation is very capable of expressing difficult passages with all possible fidelity. At a time when the language had only just been fixed, and when he had had very little practice in its use, Prof. Couturat translated into it a particularly difficult passage from the work of Gomperz (the Viennese academician) on "Grecian Thinkers." Prof. Pfaundler, without having seen the original, retranslated it at Graz from the international language into German, and sent this to Gomperz at Vienna, with the request that he would give his opinion on the accuracy of the retranslated passage. Gomperz wrote, characterizing the reproduction as "astonishingly exact, . . . the test as extraordinarily successful, and the result in a high degree favorable to the possibility of employing the international language." This test must certainly be regarded as a very severe one, because the German language is foreign to the first translator, while, owing to its philosophical nature, the subject was not familiar to the second translator as a physicist.

Finally, it may be stated that Ido, the new language, is not perfect by any means. Like every other human invention, it is perfectible. Without doubt it will have to undergo changes and improvements, for one cannot expect that such a gigantic task as the introduction of an international auxiliary language can be accomplished all at once. Ido, however, represents the first artificial language whose introduction to science deserves serious consideration.

We would urge Esperantists to co-operate with the delegation in solving the very important problem of providing the world with a language which shall be truly international. They can be of great assistance in this effort, because they are familiar with Esperanto, and ought to be able to speak the new language with very little effort.

METEORS AND THEIR OBSERVATION.

HINTS FOR THE AMATEUR.

BY W. F. DENNING, F. R. A. S.

THE observation of meteors forms an important branch of practical astronomy, and it is one which specially commends itself to the amateur astronomer. It merely needs patience and the keen use of one's eyes. The only instrument required is a celestial globe, on which the apparent paths should be penciled as observed. The R. A. and Dec. of each meteor should be recorded, together with the date, time, magnitude, duration, length of path, streak or train, and assumed radiant. A few years' watching on clear moonless nights will yield some thousands of meteors, and if they are carefully observed, and accurately registered, the student may feel satisfied that he has accumulated materials both of an interesting and valuable character.

Of course, a certain amount of practice and experience are essential before a beginner can expect to attain precision and reliability in this work. Many months of sedulous application to it can alone insure success. The writer concluded that the observation and record of 2,000 meteors are necessary before desirable proficiency can be expected; but it is certain that much depends upon individual ability. In certain cases a very extended practice in this field seems insufficient to impart the degree of accuracy required —in fact, a proportion of observers do not possess the skill or natural ability for these particular researches. In other instances, a rather limited acquaintance with the work appears to bring very satisfactory results. Experience in this, as in other researches, obviously proves that much depends upon the observer's intuitive ability. Habitual application will enable much to be accomplished; but the degree of skill attained must largely rest upon the aptitude of the individual.

Meteoric observation is still, unfortunately, dependent upon somewhat rough and hurried naked-eye estimates of position. The photographic method has practically failed to realize anticipation. Its results hitherto have been very meager; only the trails of brilliant meteors appear to impress themselves on the plates. We have still to regard the unaided eye as the main factor in providing us with materials.

This is to be greatly regretted, for so long as the old method is employed, we shall continue to hear complaints as to the inaccuracy and uncertainty of meteoric astronomy. These complaints are, in a measure, just, for a large proportion of our existing data is rendered almost useless by errors which cannot be eliminated. Considering, however, the difficulties confronting the observers, and the character of the work, I believe it to be more correct than is supposed, and that if certain obviously wild results were expunged from our catalogues, it would be an advantage.

The plan of recording meteors and shooting stars initiated by Heis, Schmidt, and others has admittedly borne good fruit. We have learned the average heights of meteors. The Leonids begin and end their luminous careers at elevations of 84 and 56 miles respectively. They are the swiftest and highest class of meteors. The Perseids are usually from 80 to 54 miles above the earth's surface. The slow-moving meteors are usually much lower in the air.

We have also learned something as to the vast number of very feeble meteoric streams scattered over the heavens, and many hundreds of their radiant points have been ascertained. Many of these require reinvestigation. The great majority of known showers may be said to be remarkable for their tenuity. Apparently, they return every year, and endure for several months, and from stationary centers of radiation. These are facts in support of which it would be satisfactory to have more ample evidence.

An immense amount of useful work yet remains to be accomplished in meteoric astronomy. It is not a subject that will ever be exhausted. It presents us with many interesting variations from year to year. A shower will be absolutely quiescent at one time, and, twelve months later, may present us with a splendid exhibition. The Andromedids of November furnish a good example of rapidly-varying strength, and the Leonids may be classed in the same category. The Perseids of August seem to be more consistent and equable in their annual manifestation, if we take moonlight, cloudy weather, etc., into account, for such differing conditions must introduce large variations in the observed strength of the display.

Any person intending to occupy himself in the meteoric field cannot do better than maintain a sharp look-out on ordinary clear evenings, and record in a book properly ruled for the purpose the apparent positions, etc., of the objects observed. There has been too much selection in the past. By this, I mean that while the April, August, and November epochs have been pretty thoroughly investigated, and the special showers prevailing at those times viewed again and again, the other seasons not signalized by rich systems have been much neglected. The reason of this is obvious. Many people find it too tedious to stand out in the open on a cold winter's night and watch meteors falling at the rate of eight or ten per hour, while there are plenty of volunteers to witness the Perseids, furnishing from 50 to 100 fine meteors in a similar interval. What we require is careful observation at times of the year which have never received adequate attention. Approximately, the winter and spring months display only half the number of meteors which appear in the summer and autumn, and this is quite irrespective of special systems. We need more data for each of the first six months of the year, though April skies have already been pretty thoroughly explored.

The direction and position of the meteor flights form the most important features to be recorded with exactness, for unless this is done, the radiant points cannot possibly be correct. Such points ought to be determined within 2 deg. of probable error, and at least five paths should be well conformable to any position before it can be safely accepted.

It has been said that the chief periods of meteoric activity in August, etc., have already been well studied; but our knowledge of the leading displays is by no means complete. If we would learn the history and nature of the variations affecting such streams as the Leonids and Andromedids, we must witness all their annual or periodical appearances. The Andromedids returned actively in 1872, 1885, 1899, and 1904, while the Leonids were moderately numerous in 1901, 1903, and 1904. No one can say whether the Leonids display a stationary or moving radiant, though the shower is certainly in visible evidence between November 7 and 19. The shifting of the Perseid radiant is already sufficiently proved; but the Lyrid shower of April requires more investigation upon this point, as the display is often feeble, and of very brief duration.

Meteoric astronomy is a department which cannot be as exhaustively dealt with as some other sections of the science. Like the cometary world, it supplies new and brilliant objects which are often unexpected. Our knowledge of double and variable stars, nebulæ, solar, lunar, and planetary details, is pretty good as a result of the telescopic work of three centuries; but there is a relatively unceasing supply of large comets and meteors from without, which render important discoveries of conspicuous objects still possible. Thus a brilliant and unknown comet came quite unannounced last January. In the allied domain of meteors we had the splendid fireballs of February 17th and 28th last, so well described by your correspondents.

The one of February 28th appears to have been widely observed, and descriptions of its aspect and course have reached me from places so distant as Steppe, near Glasgow, and Salisbury in Wiltshire. In every collection of miscellaneous data of this sort there are discordances, which serve to render their reduction a rather difficult process, and it may be well to await further information before drawing final conclusions. One thing, however, appears certain, and that is, the meteor's exceedingly low position in the atmosphere at the moment of its final disappearance. At Kington, Hereford, the observer says it appeared to touch the horizon, though he was situated 650 feet above sea level. At Leeds, its altitude was estimated at only three degrees at the finish, while in Gloucestershire it was given as two degrees. Probably it was only sixteen miles high—possible only ten or twelve—when it ceased to be luminous at a place over Ireland about thirty miles south of Cavan.—English Mechanic and World of Science.

RESINITE COMPOUND.

CONSUL THOMAS H. NORTON, of Chemnitz, says that various art industries in Germany have found a number of useful applications for a newly invented substance, termed "resinite," of which he gives an account:

This material is produced in a variety of modifications by the union of formaldehyde and carbonic acid (phenole) in connection with certain metallic salts. The name is given on account of its resemblance in an important form to ordinary resin. This special variety is used chiefly with porous materials, such as wood, paper, pasteboard, etc., and renders them hard and impermeable. Thus ordinary pine wood when thoroughly impregnated, becomes so hard that it rapidly dulls a planer.

In another form it can be poured as a liquid into molds. After coagulation it is transparent, with ruby tint, infusible, and unaffected by ordinary chemical reagents. It is well adapted for making ornaments, such as hat-pin heads, imitation jewelry, and for most purposes where enamel or enamel varnish is employed. For doorplates, street numbers, signs, etc., it seems capable of rendering excellent service, being entirely unaffected by atmospheric action.

A third modification is liquid, but upon the additions of a mineral acid, it solidifies in a few minutes to an elastic, homogeneous substance, which can be easily cut, turned, polished, etc. In this form resinite can replace for a multitude of purposes, horn, celluloid, vegetable ivory, and similar substances. Buttons, knife handles, mosaic designs, are some of the many objects made with this modification. When competing with celluloid, it possesses the great advantage of being noncombustible. This property resinite shares in common with another industrial rival of celluloid, viz., cellit (described in Consular and Trade Reports in 1908).

There is a large field for this new material in the glove manufacturing sections of Germany, where at present clasps are made chiefly from vegetable ivory.

The smallest engine in the world, says the Sibley Journal, is named "Tiny Tim." The cylinder is of steel, with a bore of 0.03 inch and a stroke of 1/32 inch. It makes 6,000 revolutions per minute, developing 1/489,000 of one horse-power. At "full load" at this speed, the eye can detect no motion of the parts, but it produces a hum like that of a mosquito. Seventeen parts complete the engine, the "net weight" of which is four grains. One hundred such engines would weigh one ounce. The bed plate is of gold, with inserted, hardened and ground, self-oiling bearings.

ELECTRICAL NOTES.

When an electrolytic cell of the aluminium type, containing a solution of a borate as electrolyte, has been in continuous operation for some time, an objectionable deposit is liable to be formed on the plate. In an invention recently patented this deposit is in great part suppressed, and its injurious effects are reduced by the addition of tartrates to the electrolyte. This also improves the character of the film in cutting down the leakage current and in raising its critical or breakdown voltage, besides reducing the resistance of the electrolyte. The solution may be made by mixing six parts of boric acid and one part of tartaric acid and then approximately neutralizing the mixture with ammonia or other alkali; or a tetraborate may be used instead of boric acid. In some cases it is preferred to add also about 10 per cent of glycerin, and, in a modification of the invention, the acidity thus produced is neutralized or partly neutralized by again adding alkali.

The New York, New Haven and Hartford Railway has recently put into operation the first regular multiple-unit train service between Port Chester and New York. The present equipment consists of four motor cars and six trailer cars. The car bodies are 70 feet long, and each has a seating capacity for 76 people. No wood is used in the construction. Each motor car weighs 173,400 pounds complete, and is intended to haul two trailers, each of which weighs 99,000 pounds. All cars are provided with quick-acting automatic air brakes. The cars operate on 11,000 volts alternating current, overhead, and 600 volts direct-current third rail. The electrical equipment of each car consists of four six-pole 150 horse-power single-phase series motors, which are geared to spring-supported quills. The quills are connected to the driving wheels in the same way as are the quills on the New Haven gearless locomotive. The motors are connected four in series, or two in series and two in parallel when operating with 600 volts direct current. On alternating current they are permanently connected two in series and two in parallel. The multiple-unit system is used, and a complete motorman's equipment is placed at both ends of every car, trailers as well as motor cars, so that the train can be operated with trailer cars in front if so desired.

According to the Electrician, a meeting of the Sub-committee of the American Railway Engineering and Maintenance of Way Association was recently held, at which reports of the Committee of the American Railway Association on the standard position of third-rail working conductors were discussed, and while no conclusion as to the amount of clearance which it would be advisable to recommend was agreed upon, it was the feeling of the Sub-committee that the clearance between the limiting lines of third-rail structures, which are shown as in 1½ inches in the report referred to, are insufficient, and that a greater clearance should be established. In order to determine the limiting clearance that should be allowed, it was decided to secure data showing the limiting lines of clearances of third-rail conductor structures, the limiting lines of rolling equipment, and the limiting lines of the third-rail structures with respect to maintenance of way structures on various railways. The Sub-committee is also collecting data from various electrified or partly electrified lines and also interurban lines with heavy traffic which may possibly interchange with steam lines, electrified or non-electrified. The Sub-committee is communicating direct with representatives of the various railways, and a circular has also been issued by the secretary of the Association requesting data pertinent to the subjects outlined.

ENGINEERING NOTES.

According to the Engineering Record, an oil separator made from an old Pintsch gas tank recovers daily from 4 to 5 gallons of oil contained in the leakage from condensing engines and feed-water pumps at the power station of the Metropolitan Elevated West Side Railway, Chicago. The drip from the machines is carried by grooves in the concrete floor to a center drain, from which connection is made to the bottom of the 150-gallon tank, the latter being below the basement floor level, so that it is under a head of about 3 feet; the outlet pipe also joins the tank at its bottom and is carried up about 3 feet at the end opposite to the inlet so as to form a trap. The comparatively slow velocity through the tank allows the oil and water to be separated; the former rises to the top of the tank, where it is trapped, and the latter flows out through the discharge pipe. Gages show the relative amounts of oil and water, and the oil is drained out at intervals through a pipe connection with a stopcock under which a pail may be placed.

A report of the Committee on Rails of the American Railway Engineering and Maintenance of Way Association includes a new form of specification. In summarizing the results of experience thus far gained with the new rail sections of the American Railway Association, the report states that experience with the heavy base sections has been disappointing. The Committee also state that, so far as they are aware, no railway company has purchased rails under specifications approved by the American Railway Association, and referred to them, neither do they know of any American railway that has succeeded in buying rails during the past two years according to a specification entirely satisfactory to the railway company. The committee's experience has brought to their attention some defects in all the specifications, and acting under the impression that there is a distinct feeling that the specifications should be revised, they offer the fresh specifications referred to. Hitherto the Association have had no specification for open-hearth steel rails, and one is now included.

J. W. Buzzell and W. H. Larkin in the Engineering News describe some experiments which were undertaken to devise an arrangement for the mechanical conveyance of concrete. The ordinary method is to convey it by wheelbarrows, carts, cars, buckets, chutes, etc., requiring enormous cost in outlay for runs, trestles, railways, engines, derricks, etc. The device used in the experiments consisted of an iron tank provided at the top with an air-tight gate, on the side with a pipe entrance for the compressed air, and at the conical bottom with an exit pipe for the concrete. Concrete was first mixed on a board at the top of the hopper and poured into the tank through the upper gate which was then battened tight. Simultaneously, then, valves on the intake air pipe and the outlet concrete pipe were opened, and the compressed air forced the concrete out of the tank through a 4-inch pipe to the point of exit. The 4-inch pipe was about 400 feet long and contained several 90 deg. bends and one 180 deg. bend round a 4-foot radius. It was found that 50 pounds per square inch pressure was the most efficient. Under this pressure the concrete mixture was forced out of the end of the pipe in a well-mixed mass, but at a velocity too great for practical work. To reduce this velocity a nozzle was devised. The main object of the experiments was to determine the amount of power necessary to convey concrete through pipes of different sizes and lengths, and the coefficient of friction between the concrete and pipe, so as to make possible the use of Bernouilli's theorem in the design of other apparatus.

TRADE NOTES AND FORMULÆ.

To Increase the Durability of Glass Lamp Chimneys.—Pack them wrapped in straw, in a pot, pour cold water on them and place the pot on the fire until it boils. The fire is then let out and the pot allowed to cool.

Bronze Fluids.—Dissolve 10 parts of aniline red and 5 of aniline violet over a water bath in 100 parts of 96 per cent spirit, adding 5 parts of benzoic acid, and boil five or ten minutes, or until the greenish color has changed to a light bronze brown. Applied with a brush, this fluid gives a splendid bronze effect.

Composition for Roof Tiles (according to Urbanitzky).—Cloth scraps (rags), hemp, straw, wood, refuse of paper manufacturing, animal hair in short lengths, etc., are made, with hydraulic lime and water, into a stiff mortar, molded into roof tiles and coated with a mixture of 5 parts hydraulic lime, 4 parts of silicate of soda and 1 part of boiled linseed oil, and finally pressed in a mold, under heavy pressure. After drying, they should be dipped in hot linseed oil and again allowed to dry.

Black Copies on a White Ground.—A solution of 10 parts gelatine, 10 parts chloride of iron, 10 parts tartaric acid, 10 parts of sulphate of zinc in 300 parts of water (according to the Chemiker Zeitung) should be applied to paper, by means of a brush, then dried and exposed to the light under a drawing until the greenish color of the copy paper has disappeared; it is then developed by means of a solution of 20 parts of gallic acid in 1,000 parts of water, to which 200 parts of methylic alcohol has been added.

Curaçao Liqueur, Dutch (according to Campe).—Bitter orange oil 20 parts, oil of sweet orange 8 parts, cumin oil 2.5 parts, oil of Curaçao peels 4 parts, cognac oil 0.5 part, lump sugar, good, 16,000 parts, potato syrup 1,000 parts, tincture of fresh green orange skins (1 : 3) 300 parts, spirit (90 per cent) 28,000 parts, adding water to make up 56,000 parts. For coloring, use color made from burned sugar. If price is not too much of a consideration, use, in place of the oil of cognac, 1,000 parts of cognac and leave out 500 parts of spirits.

Cupro-Manganese is an alloy of 70.5 parts of copper, 25 parts manganese, 0.5 part carbon. Alloys of same: *a.* 16 parts tin, 3.5 parts zinc, 3.5 parts lead, 1 part cupro-manganese. *b.* 16 parts tin, 3 parts zinc, 3 parts lead, 2 parts cupro-manganese. *c.* Tombac: 85 parts copper, 14 parts tin, 1 part cupro-manganese; or 81 parts copper, 17 parts tin, 2 parts cupro-manganese. *d.* White brass: 42 parts tin, 40 parts lead, 16 parts antimony, 2 parts cupro-manganese; or 20 parts tin, 58 parts lead, 20 parts antimony, 2 parts cupro-manganese.

Black Oxide (J. Rhein.)—Coat the object with oily copal lacquer, brush it over with graphite, thoroughly washed, as it is prepared for use in lead pencil manufacture, dust off with a hair brush and dry. There are two methods of application—gentle rubbing with a hair brush, or use of a soft bristle brush. In the former method, the object must be brushed, after drying, with a rather stiff hand-brush, until a high luster is produced. If the bristle brush is used, it is to be handled as in bronzing, and the polishing can be done with a soft brush or with wash leather. A brilliant luster is thus produced before drying, and subsequent brushing is not necessary. The object is now to be coated with a mixture of 2/3 copal lacquer, without much oil, and 1/3 turpentine oil, applied so abundantly that the smooth parts become as bright as a mirror; a second coating of graphite is to be applied, and the object dried at once in a warm place. The first drying must be thorough, but the objects must not be subjected to too much heat, as this would turn the coating greenish. Finally it is coated with wax dissolved in turpentine, wiped with a clean cloth and polished with wash leather.

Black Oxide (J. Rhein.)—This is for a steel colored coating. Treat the object exactly as above, as far as to the wax coating; instead of this, put on Prussian blue rubbed up in turpentine oil. Dilute the blue from time to time with wax turpentine, or with turpentine oil. It may be very thin, as a little will go a long way.

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